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LIVINGSTON WIND ENERGY SYSTEM: A MUNICIPAL COMMERCIALIZATION PROJECT: JUNE 1981 - NOVEMBER 1982

Prepared for

MONTANA DEPARTMENT of NATURAL RESOURCES and CONSERVATION

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LIVINGSTON WIND ENERGY SYSTEM: A MUNICIPAL COMMERCIALIZATION PROJECT: JUNE 1981 - NOVEMBER 1982

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December, 1982

Prepared for

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ABSTRACT

Livingston, Montana is an area of known high wind energy potential. Since the mid-1970's a number of extensive wind monitoring studies have been carried out to statistically quantify the resource. Based on the potential indicated, the City of Livingston and State of Montana have engaged in designing and constructing the nation's first municipal wind farm. This wind energy system is also the state's first commercial alternative energy facility, interfacing with the private utility's energy grid system under PURPA provisions. Since on-line operation ensued in December 1981, valuable performance data, as well as fiscal revenue and expense tracking have made important contributions toward projecting economic viability for commercial wind electric conversion systems.

In addition to, and to a degree a direct result of, the Livingston Wind Farm, spinoffs associated with the project have included both continuing public and private sector efforts toward wind energy application. The U.S. Department of Energy's 45 meter monitoring tower has been taken over by the Bonneville Power Administration and additional Small Wind Electric Conversion System (SWECS) units have been placed in the area to gain further performance data by the State of Montana, as well as various private sector groups.

A Chicago manufacturing firm has relocated and hired local people for wind generator fabrication, and other major generation and manufacturing projects are under active consideration.

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I. BACKGROUND

Project History

Beginning in the mid-1970's, serious thought was given to the potential resource that wind represented for generation of electricity. At this same time, the Montana State Legislature, voting in session in 1975, authorized and appropriated 2.5% of the state's Coal Severance Tax revenues for creation of an Alternative Renewable Energy Sources program. The creation of this new state bureau put in place a funding mechanism for research and development of alternative energy, and from the very onset, attention was focused, in part, on the Livingston area for acquiring quantifiable data through wind monitoring studies. By late 1978 and early 1979, the accumulated data base, cross-referenced with over fifty years of Federal Aviation Administration - Flight Service Station readings, was already demonstrating enormous available annual wind power, exceeding 500 watts/M^2, with peak months in excess of 1,000 watts/M^2. Early projections of 14 mph average wind speeds were corrected to mean annual speeds of over 16 mph. Winter monthly average wind speeds exceeded 23 mph (Figure 1). The data collected was further qualified by historic records which indicated that the latter half of the 1970's averaged lower wind speeds than has been traditionally true of the area (Figure 2).

It became evidently clear through the research data being analyzed that the time for demonstration and commercialization of the wind resource was at hand. The quickly escalating cost of electricity generated by fossil fuels lent further viability to such development.

Project Conception

With continued wind monitoring programs providing the stage on which to act, the City of Livingston and its consulting engineers, the Montana Energy and Research Development Institute (MERDI) designed a program for the placement of an array of Small Wind Electric Conversion Systems (SWECS) to supply the electrical power for the city's planned expansion of its sewage treatment plant.

The waste-water facility was being designed for peak-load power requirement

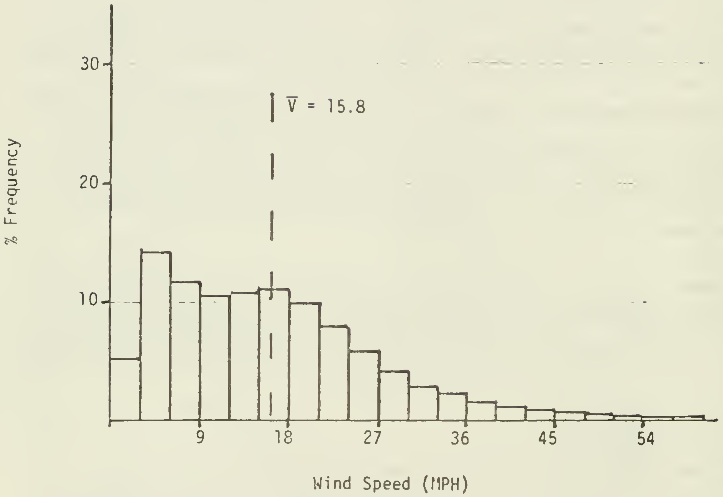

Figure 1. Wind Speed Frequency Distribution for Livingston from March 1980 through March 1981.

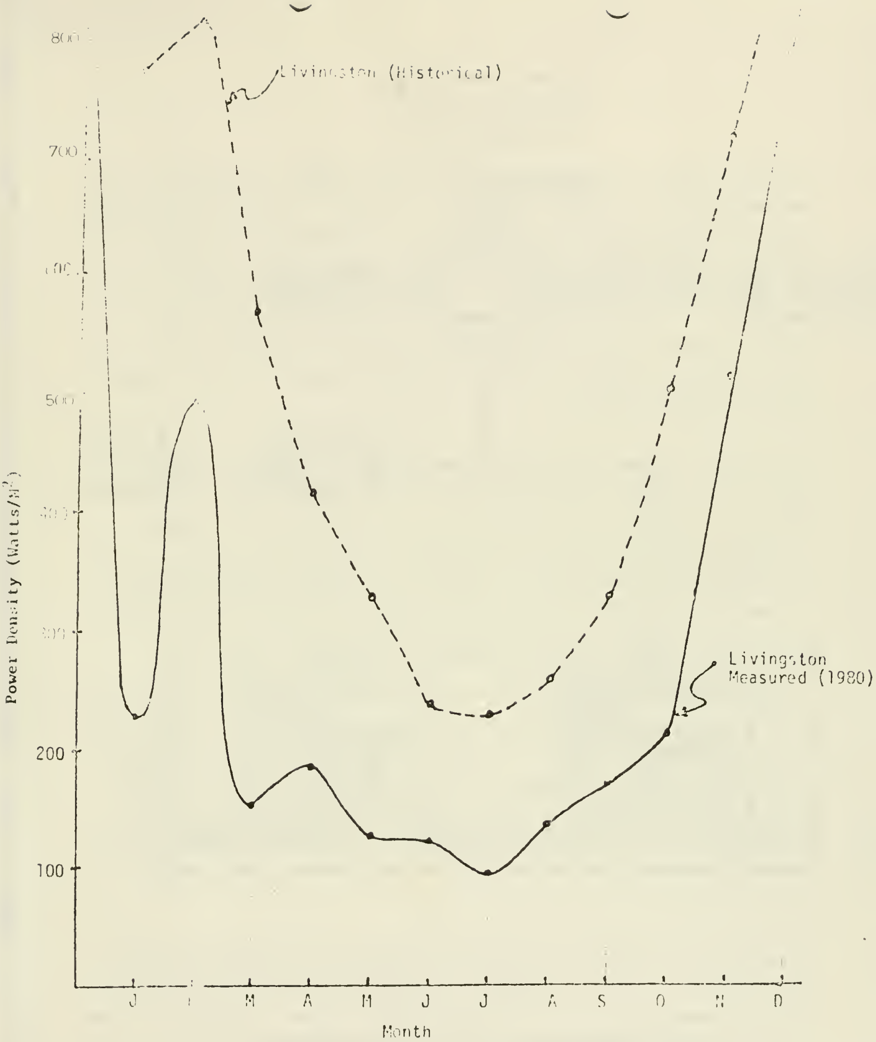

FIGURE 2. Power Density by Month for Historical Data and 1980-1981 Measured Data

of 200 hp. After reviewing the state-of-the-art SWECS then available on the commercial market, a tentative selection of eight (8) Jay Carter Enterprises Model 25 kw wind turbines was arrived at. By designing a 'wind farm' of 8 units, a 200 kw total electrical generating capacity could be reached, enough to offset the projected power demand of the sewage treatment plant (Figure 3). The old city-county airport, located on the bench lands known as Harvat's Flats, would gain the city full access to the Yellowstone River wind corridor while providing siting only one-half air-mile distant from the treatment plant.

The idea then became to develop and demonstrate an alternative energy source while applying generated electricity to an environmental improvement project. Further, by underwriting the electrical costs of the sewage treatment plant, local tax-derived revenue could be held in check to a small degree,benefitting taxpayers in a federally-designated 'economically distressed' rural community. Also, U.S. Interstate 90 bisects the wind farm site, insuring high public visibility for the proposed project.

An unsolicited formal application was put together, incorporating a scope of work designed to improve state-of-the-art technology within the SWECS field, and was submitted in June 1979, to Rockwell International, sub-contractors to the U.S. Department of Energy (DOE) at the Rocky Flats Test Facility. With written support from Montana's governor, the state director of the Department of Natural Resources and Conservation (DNRC), the Montana Public Service Commission (PSC) and the state congressional delegation, quick action was hoped for; this was not to be.

In July of 1979, Rockwell International responded to the city's proposal, rating the application "technically sound and pertinent". But due to a lack of federal funding for the national SWECS program, the application was declined. At the suggestion of the Rocky Flats staff, the application was re-submitted to the DOE central office in Washington, D.C., while another copy was forwarded to the White House for staff concurrance.

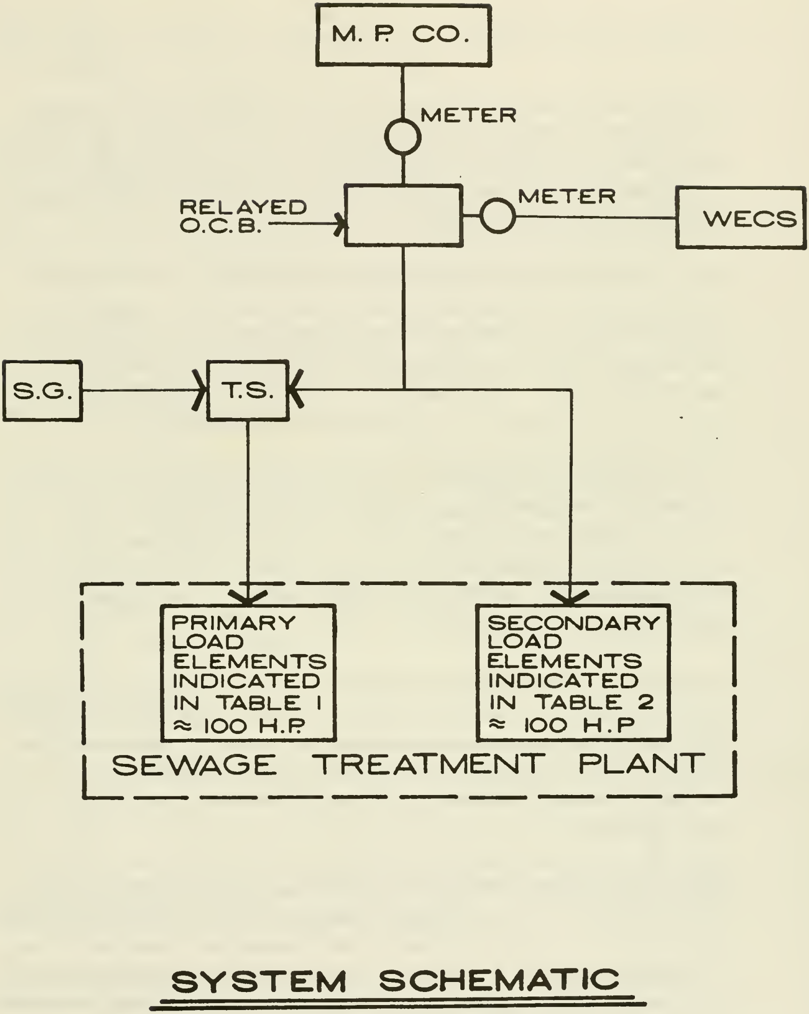
M. P. CO.
METER
RELAYED O.C.B.
METER
WECS
S.G.
T.S.
PRIMARY LOAD ELEMENTS INDICATED IN TABLE 1 ≈ 100 H.P.
SECONDARY LOAD ELEMENTS INDICATED IN TABLE 2 ≈ 100 H.P
SEWAGE TREATMENT PLANT
SYSTEM SCHEMATIC

FIGURE 3. SWECS AND SEWAGE PLANT INTERFACE

The grant application was directed to the Wind Systems Branch of the DOE. By the beginning of 1980, review was completed and the request for funding was determined "pertinent, but unsolicited". Apparently a 'Pandora's box' would be opened by the award of an unsolicited proposal not corresponding to a Program Opportunity Notice.

During this period, the Regional Administrator for the U.S. Environmental Protection Agency (EPA) learned of the proposed program and expressed interest in the EPA reviewing such. With the declination of the DOE for any funding, a revised and updated project application was submitted to the EPA in June 1980. Incorporated with the revised application were provisions for interfacing with the Montana Power Company's (MPC) energy distribution grid system. The potential for selling the power from the wind farm directly to the general utility was allowed for to minimize the probability of damage to sewage treatment plant monitoring gear. By utilizing a double metering system -- a credit-debit arrangement -- we also could explore the area of grid tie-in allowed for under the Public Utilities Regulatory and Policy Act (PURPA) mandated by the Congress in 1978.

Formal EPA review got under way during the summer of 1980. The first hurdle was the neccessity of determining whether the wind energy system was within 15% cost-effectiveness of a conventional energy source, as required by EPA Innovative Technology regulations. Disallowed to be factored into the formula for determination were projected escalations in conventional electricity costs.

The City of Livingston petitioned the Grants Administration Office of the EPA in Washington, D.C. in a deviation request for waiver of that particular exclusionary rule. After some debate, and congressional investigation, the city received allowance for factoring in electrical rate increases within the projected minimum 20 year life of the facility. The Municipal Environmental Research Laboratories (MERL) of the EPA, in Cincinnati, Ohio, then determined that the project was competitive with conventional energy sources.

This was the first such determination of the cost-effectiveness regarding wind energy made in this country at that time.

In November of 1980 the City of Livingston received tentative grant approval from the EPA for 85% of the total project cost of $355,000. The EPA required 15% matching funds and application for this remaining balance of the Wind Farm Project was made to the Montana DNRC's Alternative Renewable Energy Sources fund. The DNRC made a tentative award in December 1980, which was made definite by action of the state legislature in early 1981.

The EPA required that the wind energy project be handled in three (3) steps; an Environmental Assessment phase, a Design phase, and finally a Construction phase. Each phase depended on the review and approval of the previous phase before grant monies could be issued.

The city then officially contracted with its consulting engineers and undertook the Step 1 Environmental Assessment in February 1981. By April, and in time for the public hearings on environmental impact, Reagan Administration cutbacks in federal FY 1981 funding virtually froze all pending and tentative EPA grant awards in their tracks. The city subsequently received word of an indefinite deferral in design and construction funds for the Wind Farm Project by the EPA.

Project Implementation

In very short order, the city conferred with its consulting engineers, came up with a limited scope project, having reduced the number of wind turbines from eight (8) to four (4) units, and submitted a grant amendment to the state DNRC for full funding of a $222,000 Wind Farm Project; award was made in June 1981, and with the change in scope, the project was re-oriented from a demonstration program to an actual commercialization of alternative energy, also the first of its kind in the state (Figure 4).

With a new target date of the last week of December 1981, for installation and on-line capability, a further hurdle was encountered. The City of

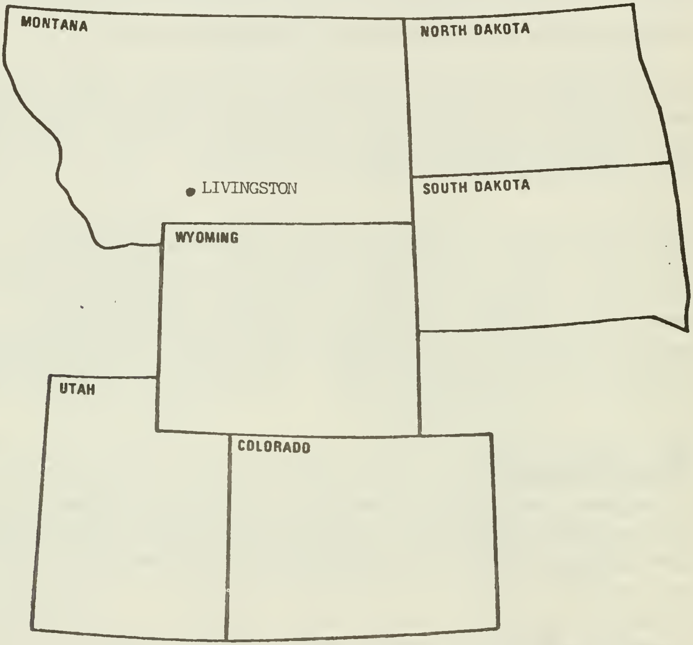

Figure 4. Location of Livingston, Montana

Livingston found itself months ahead of the determination, by the state PSC, of a final buy-back rate, as per federal PURPA mandate. Working closely with the PSC, the city negotiated directly with the MPC to establish the first interim buy-back rate contract in the state. At that time the city was looking at a credit of 2.5¢ per kw hour, with a bonus credit of .5¢ per kw hour, if a 60% capacity factor was reached over the life of the contract. The term of the interim contract would be until determination and establishment of the final state-wide buy-back rate, which was made in the early spring of 1982. The two other major areas confronting the city regarding negotiations on the buy-back contract were the costs incurred by MPC of upgrading power lines to make them compatable with the wind farm's power frequency, including the terms of payment, and MPC's requirement for liability coverage on the energy system.

It was determined, per the interim Small Power Production Agreement between the city and MPC, that 8,750 feet of new power line would be necessary in order to bring the city's Qualifying Facility into proximity with the MPC grid. The cost for 3-phase 480-volt line would be approximately some $17,000. The city additionally was required to pick up liability insurance coverage, in the amount of one million dollars for personal damages and occurance damages, and $300,000 coverage for property damages. Insurance costs carried by the city in this regard amounts to $1,300 per year for the wind farm facility, at this time.

The interim buy-back rate for electricity generated by the Livingston wind farm was superceded by a final rate determination per PSC order effective March 22, 1982. The rate established at that time for a long term contract was 4.09¢ per kw hour. At that time, also, the city elected to sign for capacity at a factor of 23.9% which entitled the city to a total rate of 5.19¢ per kw hour. In August of 1982 the base rate for Small Power Production Contracts was escalated to 5.33¢, plus the previously agreed to 1.1¢ capacity payment, for a total buy-back rate of 6.43¢ per kw hour.

II. INTRODUCTION

This section summarizes the activities leading to the establishment of a fully operational wind farm at Livingston, Montana. The activities discussed include Basic Design, Site Selection, Final Design, Construction Activities, and Check-Out and Start-Up and covers services performed prior to contract award on July 6, 1981 through August 1982. Contractually this final report was due at the conclusion of the Check-Out and Start-Up, initially in December 1981. However, immediate and severe problems with the wind machines indicated this task was not complete and was repeated in late April 1982. The reporting period was extended through the fall and winter of 1982 to insure that Check-Out and Start-Up was indeed complete, and to include operational history of interest to the City of Livingston and the State of Montana Department of Natural Resources and Conservation.

Livingston Wind Farm

The present Livingston Wind Farm is comprised of four 25-kw wind generators, each of which has an individual control system, electrical interface system, and are connected as a unit with the MPC electrical grid. The design, construction, and initial start-up of the wind farm was completed on December 22, 1981.

The project site is located on the bench area near the City of Livingston, between the mountains to the east and the Yellowstone River to the west. This site area is approximately one mile east and slightly north of the city.

The specific location of the wind farm and the machines is in the southeast corner of an area known as the old Livingston Airport, as shown in excerpts from the site plan drawing (Figures 5 and 6).

Project Engineers

The contract between the City of Livingston and MultiTech, Inc. for the wind farm project was completed and signed on July 6, 1981. However, MultiTech's work on the project actually started two years prior to that date during their involvement with several other wind energy projects in the Livingston area.

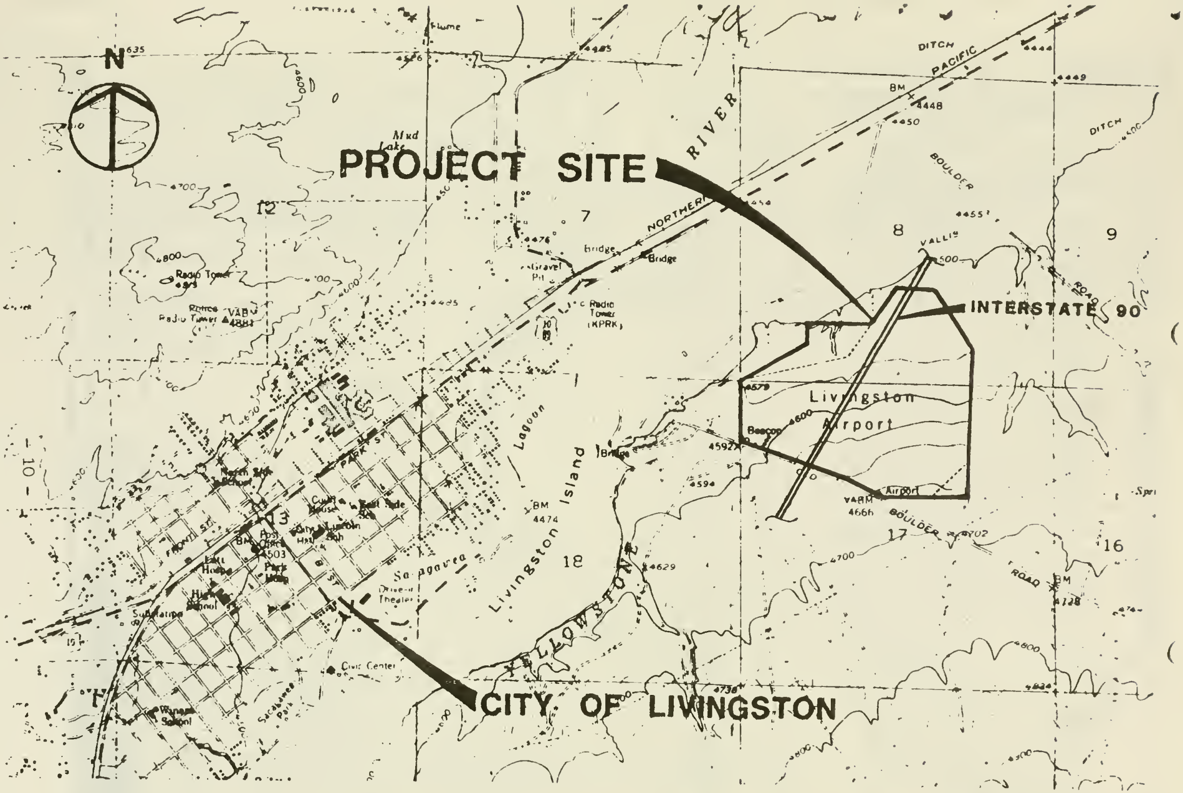

FIGURE 5. -- **VICINITY MAP** (Drawing Excerpt)

APPROX SCALE 1" = 2,000'

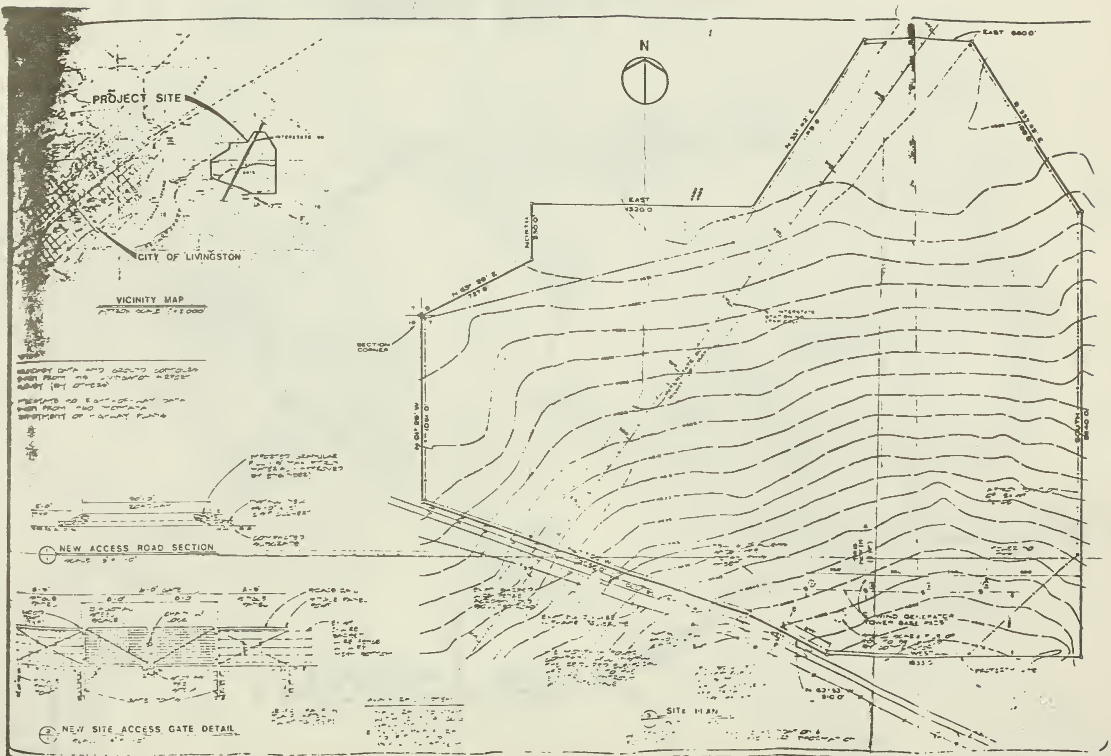

FIGURE 6. WIND FARM
LIVINGSTON, MONTANA

SITE PLAN & VICINITY MAP

In June of 1979, MultiTech was contracted by the Montana DNRC for the Montana Wind Energy Research and Development Project. The objective of this project was to monitor the wind and assess the wind energy potential in the Livingston, Big Timber and Whitehall areas. As a part of this same project, a 25-kw wind generator was installed in the Livingston area for the MPC on May 2, 1980. The wind monitoring data and the power output data collected during this project enabled MultiTech personnel to accurately assess the wind energy potential for all three areas, and make accurate projections regarding output of wind generator units in the Livingston area (Figure 7).

In September of 1980, MultiTech began collecting wind data in the Livingston area from a 45-meter monitoring tower for the DOE and the MPC. This wind data was collected from three levels on a 45-meter tower; i.e., at 10 meters, 30 meters and 45 meters. The wind data from this project provided further information with which to assess the resource potential at Livingston. This monitoring project is still under way, now under BPA auspices.

Project Funding

Realizing the substantial wind potential in the Livingston area, MultiTech, with the City of Livingston, submitted, in late 1980, a proposal to the Environmental Protection Agency (EPA) for an eight-unit wind farm. The wind farm, comprised of eight 25 kw wind generators, with a yearly electric output of approximately 472,000 kw hours, would have provided electric power to operate the city's new sewage treatment plant. EPA was interested in the project and decided to initiate a three phase project comprised of an environmental assessment, design and construction. The environmental assessment was completed by Christian, Spring, Sielbach and Associates (CSSA), the engineering firm for the sewage treatment plant, and MultiTech. The applicable environmental assessment report is available in a separate document, dated March 24, 1981.

In early 1981, when it became apparent that the EPA would not have a sufficient budget to fund the remainder of the project, the wind farm proposal was re-submitted to the DNRC. Because of DNRC's limited budget, the size of the wind farm was reduced from eight to four 25-kw wind generators, thereby enabling the project to be funded.

FIGURE 7.

ESTIMATED POWER OUTPUT OF CARTER WIND TURBINE AT VARIOUS WIND SPEEDS
(DATA TAKEN AT LIVINGSTON SITE)

WIND SPEED RANGE (MPH)	MID-POINT (MPH)	POWER DENSITY (WATTS/M^2)	TOTAL POWER AVAILABLE IN CARTER SWEEP KILOWATT/HRS	% EFFICIENCY AT THIS WIND SPEED	ESTIMATED KILOWATT/HRS CARTER TURBINE	ESTIMATED KILOWATT-HRS PER MONTH
0-3	--	--	--	--	--	--
3-6	--	--	--	--	--	--
6-9	--	--	--	--	--	--
9-12	10.5	58	4.33	12.5	0.5	360
12-15	13.5	123	9.18	40.0	3.7	2660
15-18	16.5	225	16.8	38.0	6.4	4610
18-21	19.5	372	27.8	33.0	9.2	6620
21-24	22.5	571	42.6	28.0	11.9	8570
24-27	25.5	831	62.0	25.0	15.5	11160
27-30	28.5	1160	86.6	19.0	16.5	11880
30-33	31.5	1567	117.0	17.5	20.5	14760
33-36	34.5	2058	153.6	14.5	22.3	16060
36-39	37.5	2643	197.0	12.5	24.6	17710
39-42	40.5	3329	248.0	10.0	24.8	17860

During April, May and June of 1981, extensive negotiations occurred between MultiTech, City of Livingston, DNRC, MPC and the wind generator manufacturer, Jay Carter Enterprises (JCE of Burkburnett, Texas).** These negotiations were necessary to initiate the planning that would result in a timely completion of the wind farm project. On June 27, 1981, a contract was formally concluded between the City of Livingston and DNRC, and on July 6, 1981, a contract between the City of Livingston and MultiTech was completed and signed; thus, the project was formally under way.

** Note: Now incorporated as Carter Wind Systems, Burkburnett, Texas.

III. WIND FARM DESIGN AND CONSTRUCTION

Project Preparation

When the wind farm project formally started in July of 1981, most of the site selection and basic design phases had already been completed. A significant milestone completed during this period was the formal selection of the Model 25 wind generator, furnished by JCE, as the machine to be installed at the wind farm. A description of the machine is contained in the specification used in the city's advertisement for bids. During the final design phase of the project, conducted in July and August of 1981, MultiTech contracted with CSSA to assist in the final design of the electrical interface and preparation of the final construction drawings.

When the final design package was completed by MultiTech and CSSA, a request for bids was initiated by the City of Livingston for contractors to complete the construction of the civil and electrical site preparation phases of the project. (Bid specifications and drawings are contained in separate documents.) Taylor Construction Company of Bozeman, Montana was selected to perform the construction phase of the project. Taylor Construction Company completed the construction of the foundations, fences, gates and the electrical interface system during September of 1981 (Figure 8),electrical work being sub-contracted to Volk Electric of Livingston.

As a consequence of extensive discussions and coordination, the MPC was requested to provide necessary transmission facilities at the wind site. The existing power line passing near the site was judged to be too small (2-wire, single-phase) to accommodate the electrical output of the wind generators. Therefore, MPC constructed a new power line to the site (4-wire, 7200-volt line, approximately one and one-quarter miles long) to meet the increased demand. The MPC also constructed the underground power feeder lines from the overhead power line to the site of generator No. 2. At this point MPC installed the necessary pad mounted transformers and the metering system for billing purposes; also, MPC's portion of the construction was completed during September 1981 (Figure 9).

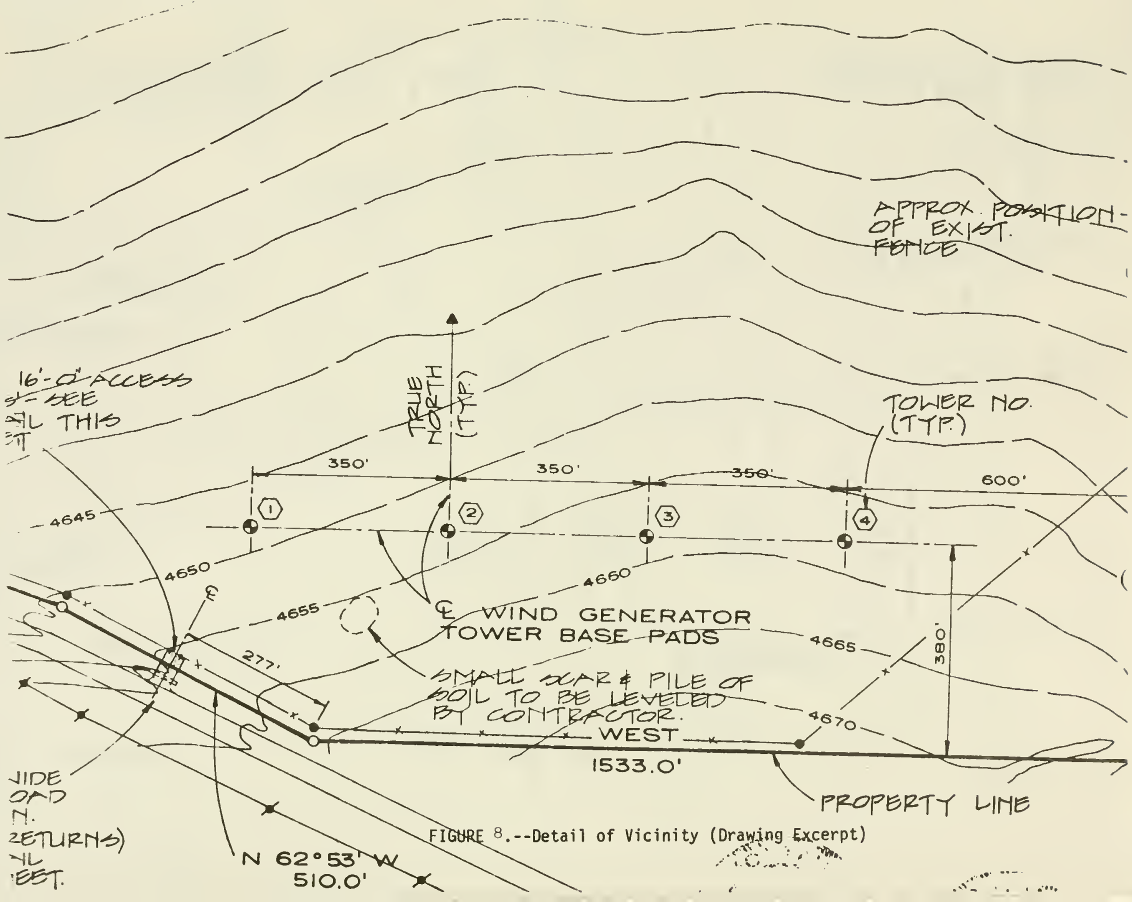

FIGURE 8.--Detail of Vicinity (Drawing Excerpt)

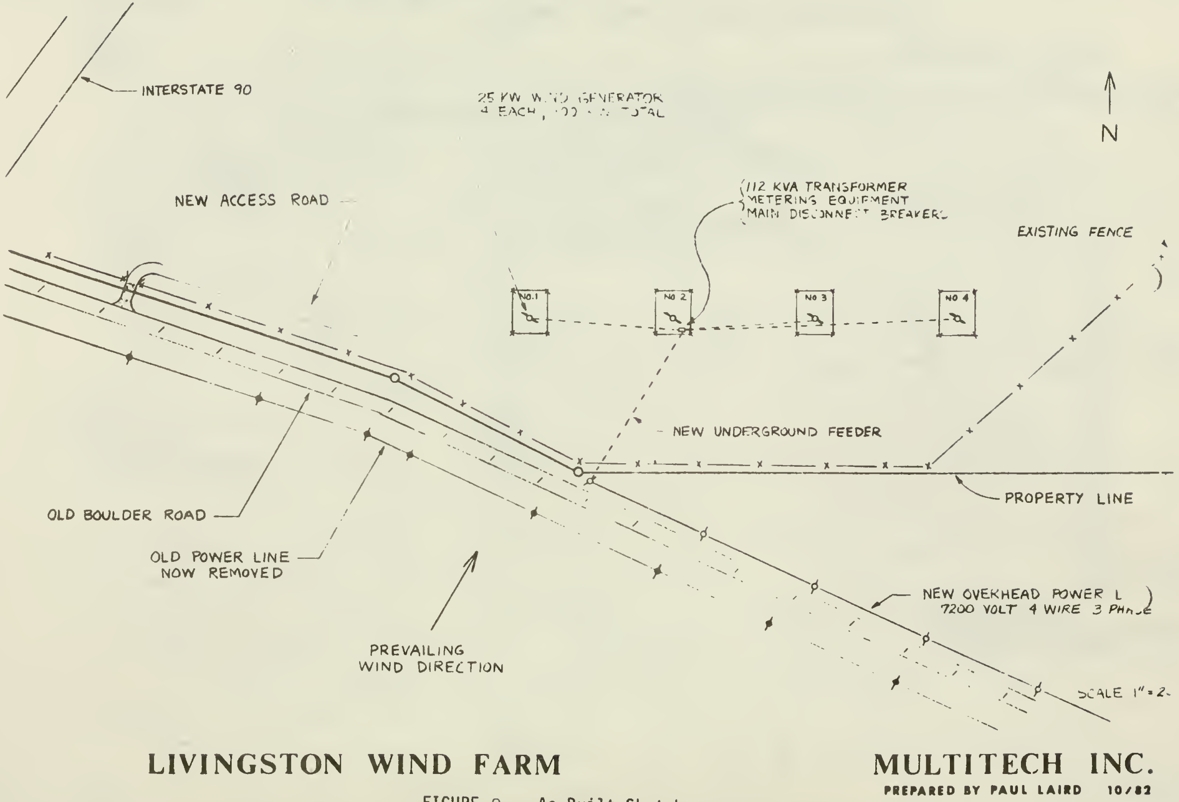

FIGURE 9. --As-Built Sketch

Project Installation

The original project schedule called for installation of the wind generators by JCE during October of 1981. However, due to manufacturing problems and conflicting delivery schedules, that original date was slipped several times. The actual installation of the wind generators was accomplished during the period from December 11 to 22, 1981. MiltiTech personnel were present at the wind site and participated in the installation of the wind generators during the entire procedure, as did city personnel to a degree.

On December 21 and 22, 1981, the wind generators were started up, and the check-out and 'debugging' period was begun. An operation and maintenance class was conducted at the wind site by personnel from JCE and MultiTech to instruct the City of Livingston operation personnel. At this training session the city operators were presented with operation and maintenance manuals prepared by JCE. The operators were also given a document entitled "Recommended Maintenance Procedures", prepared by MultiTech personnel. This concluded the design, construction and installation phases of the project (Figures 10 and 11). Copies of close-up photographs showing the tower base, the generator on top of the pole and full length perspectives are shown in Figures 12 and 13 .

FIGURE 10. COMPLETED WIND FARM WITH PROJECT SIGN

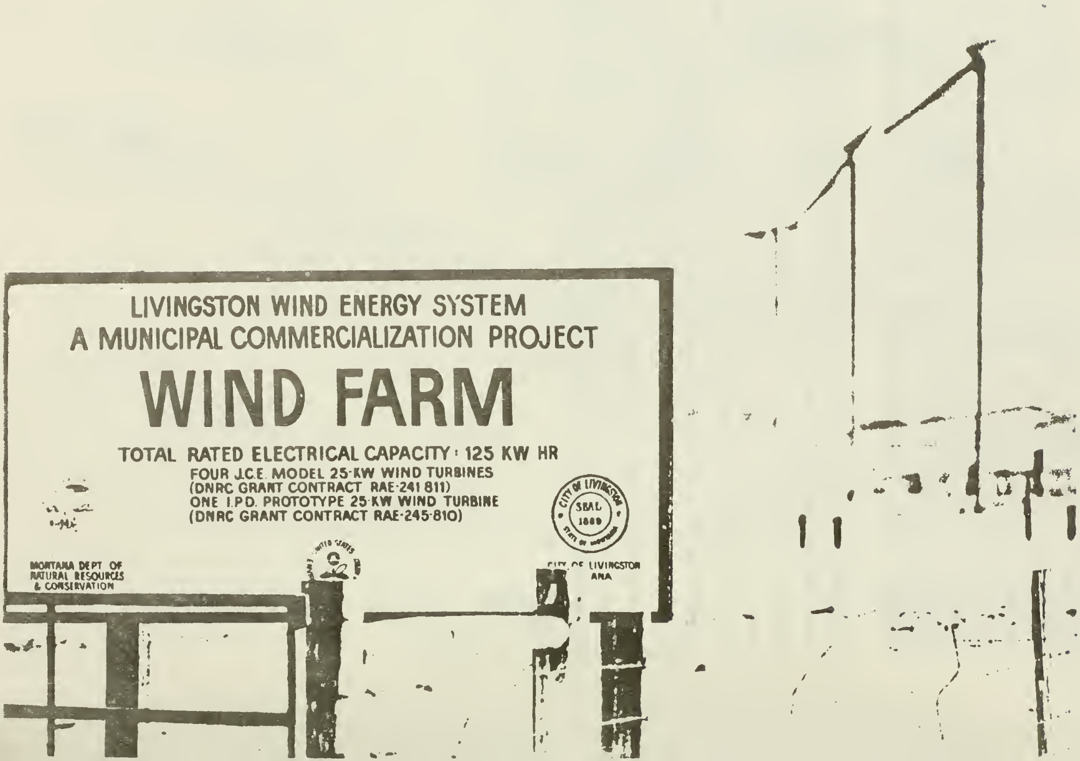
LIVINGSTON WIND ENERGY SYSTEM
A MUNICIPAL COMMERCIALIZATION PROJECT
WIND FARM
TOTAL RATED ELECTRICAL CAPACITY: 125 KW HR
FOUR J.C.E. MODEL 25-KW WIND TURBINES
(DNRC GRANT CONTRACT RAE-241 811)
ONE I.P.D. PROTOTYPE 25-KW WIND TURBINE
(DNRC GRANT CONTRACT RAE-245-810)
MONTANA DEPT OF NATURAL RESOURCES & CONSERVATION
CITY OF LIVINGSTON SEAL 1889 STATE OF MONTANA
CITY OF LIVINGSTON
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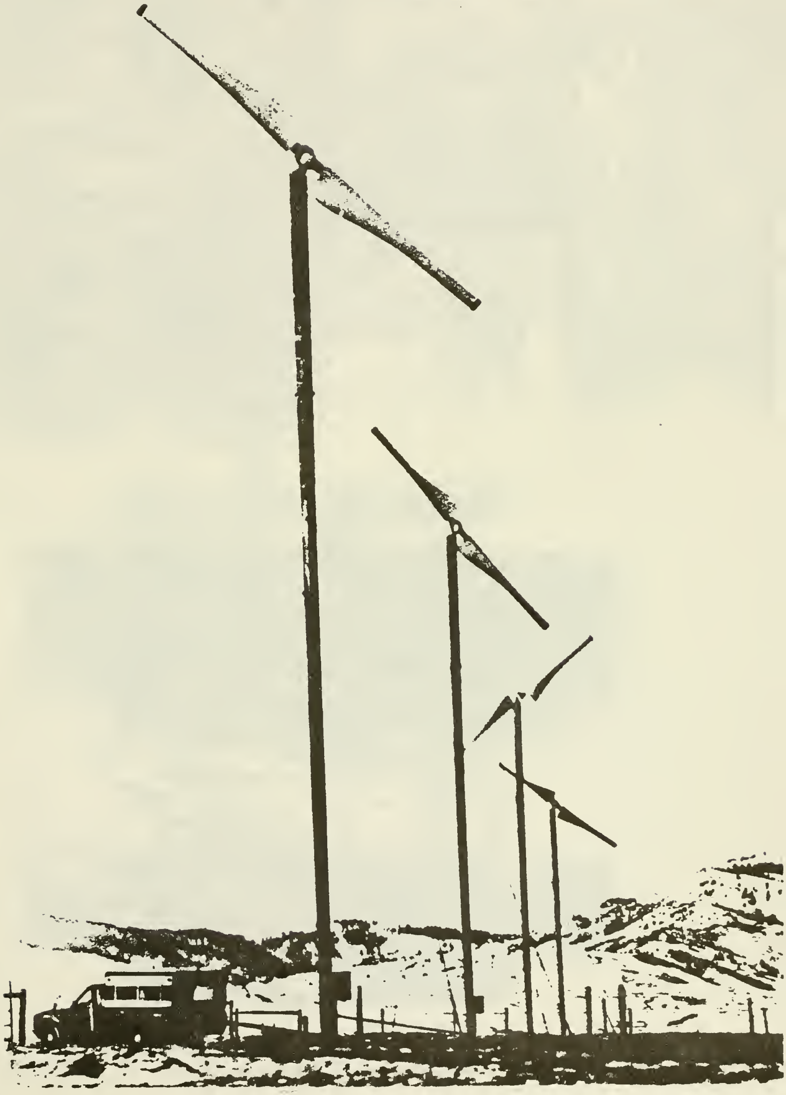
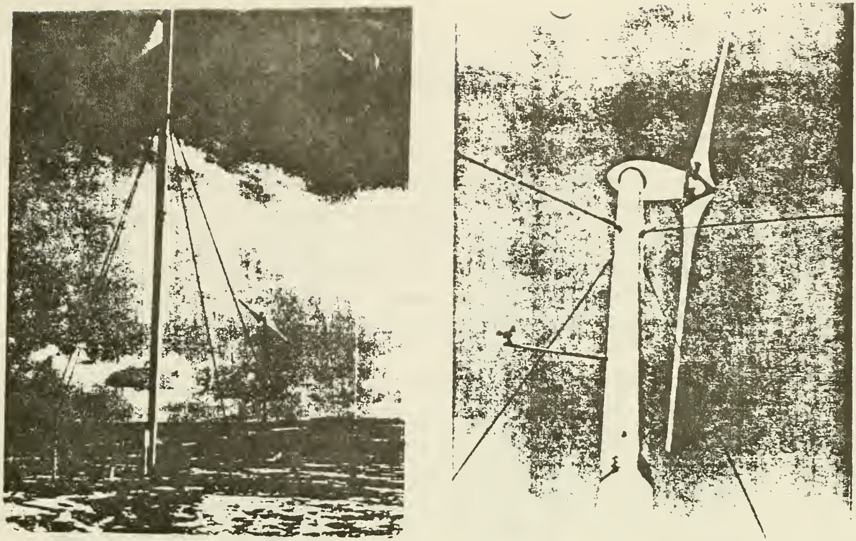
FIGURE 11. COMPLETED WIND FARM WITH ELECTRIC GENERATORS



Electrical Control Enclosure

Tower, Foundations, and Guy Wires

FIGURE 12.--Close Up Photographs



Carter Wind Systems 25 Kilowatt Generator

Livingston Wind Farm

FIGURE 13. .--Close Up Photographs

IV. WIND FARM OPERATION

On-Line

The wind farm became fully operational on December 22, 1981, when an acceptance inspection was performed by MultiTech personnel. On that date, all four wind generators were completely installed and operating, as specified in the city's contract with JCE. Unfortunately the wind farm managed to operate successfully for only two weeks; at that time a series of problems caused the wind generators to be shut down for 16 weeks.

Starting on December 25, the first of four separate instances of automatic stoppages of the machines by the out-of-balance brake was experienced. The brake is provided to prevent major damage in the case of an out-of-balance condition due to either gusty winds or equipment failure. The machines can't be re-started from the ground; however, the more prudent procedure is to lower the machine. inspect for equipment problems, and then re-set the out-of-balance brake, and raise and re-start the machine. The three affected machines were lowered and inspected with a determination that gusty winds were the cause for the out-of-balance brake being set. Similar occurances were experienced on December 28, 30, 1981 and January 4, 1982. Due to the frequency of the brake being set, JCE instructed MultiTech to inspect the setting of the force required to initiate the brake mechanism. It was discovered that the out-of-balance mechanism had been set inadvertently too low at 3-G's at the factory. At JCE's request, MultiTech re-set the braking level to 4-G's, which has solved the out-of-balance brake problems. However, the benefit of the change was not fully realized as other problems prevented machine operation until late April 1982.

Failure Mode

A scheduled two week inspection of the wind generators was planned for January 7, 1982. When MultiTech personnel arrived at the wind farm, the No. 4 generator was found on the ground and completely destroyed. The reason for the catastrophic failure was not immediately determinable. JCE was notified of the failure on January 7, 1982 and immediately recommended that all of the generators should be shut down until a failure investigation could be completed (Table 1 - Figure 14).

TABLE 1.

NO. 4 MACHINE FAILURE

SIGNIFICANT FACTS

- MPC Power Line Experienced Outage
- Cotter Pin of Up-Wind Guy Wire Sheared
- Tower Failed Structurally - Joint at Midsection and at Base
- One Blade Separated From Spar and Was Found Relatively Undamaged 250 Feet to 300 Feet Downwind

FAILURE DETERMINATION

- Jay Carter Enterprises Experience and Testing Indicates a Thickening of the Hydraulic Fluid in Cold Temperatures Caused Various Braking Mechanisms to Perform Abnormally, Thereby Resulting in Machine Failure.

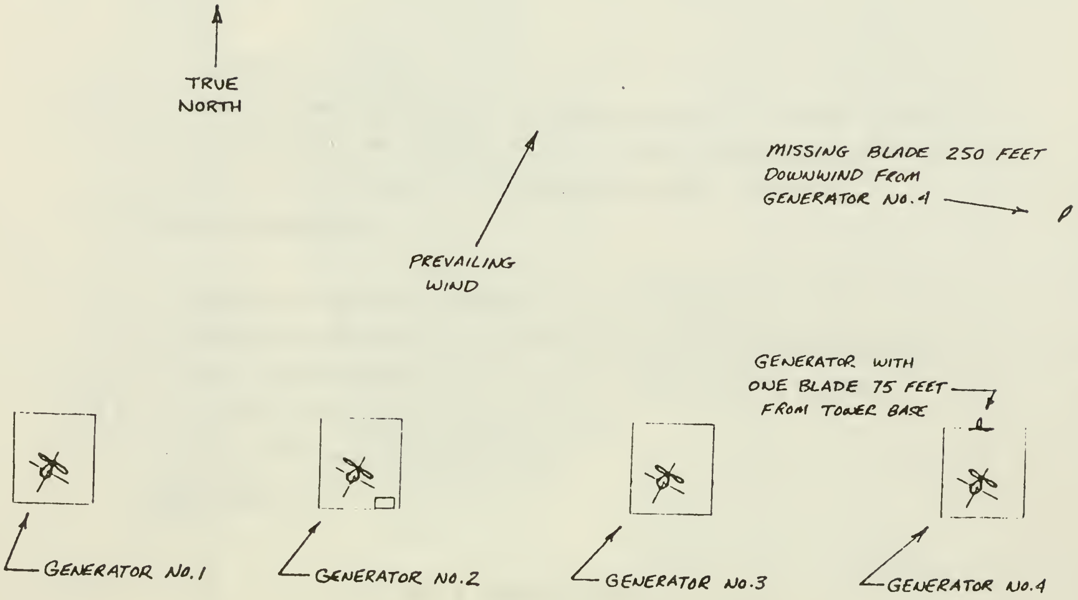


FIGURE 14. NUMBER 4 MACHINE FAILURE

On January 10, Jay Carter, Sr. and a representative from MultiTech visited the wind farm to initiate the failure investigation which continued for several weeks. The cause of the failure was eventually determined to be inadequate functioning of the blade pitch-up mechanism. The blade pitch-up mechanism is intended to stall the air-foil blade and stop the generator in the event of an overspeed condition.

The chronological sequence of events that led to the destruction of generator No. 4 are as follows:

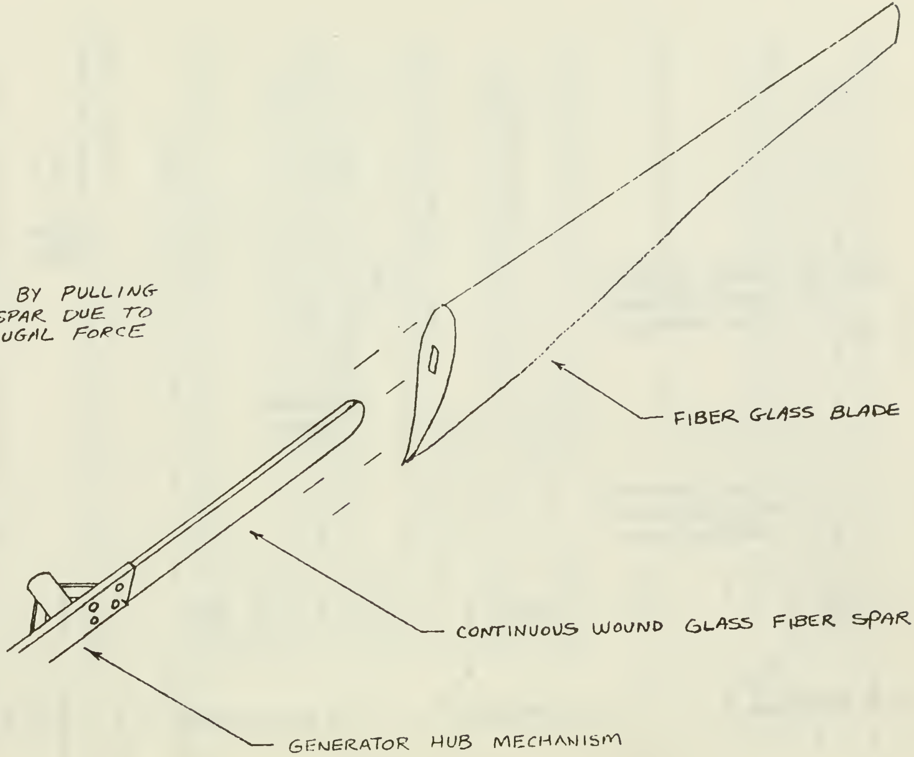
1. A power failure on the MPC power line caused the generator to go into a normal overspeed condition.
2. Due to a sticking pitch-up mechanism and a sluggish hydraulic pitch-up blade snubber, the overspeed continued until an extreme overspeed condition existed.
3. This extreme overspeed caused one blade to fail and fly off of the generator, causing an excessive out-of-balance condition to exist (Figure 15).
4. The excessive out-of-balance condition caused the support pole to twist apart, and the generator to separate from the top of the pole. The generator was destroyed upon impact with the ground (Figures 16 and 17).

During the failure investigation, Jay Carter, Jr. assured the city that the generator would be replaced under the provisions of their warranty.

During the period of failure analysis and manufacturing of replacement parts, two other component problems were discovered, i.e., blade cracking and reduction gear quality control.

On January 26, 1982 it was discovered that the fiberglass blades on generators No. 1, 2, and 3 were developing cracks in their surfaces. The entire wind farm had been shut down since January 7. Again JCE was notified, and another failure investigation was started.

On February 1, Jay Carter, Jr. and a representative from MultiTech visited the



BLADE FAILED BY PULLING
LOOSE FROM SPAR DUE TO
HIGH CENTRIFUGAL FORCE

FIGURE 15. NUMBER 4 MACHINE FAILURE; BLADE DETAIL

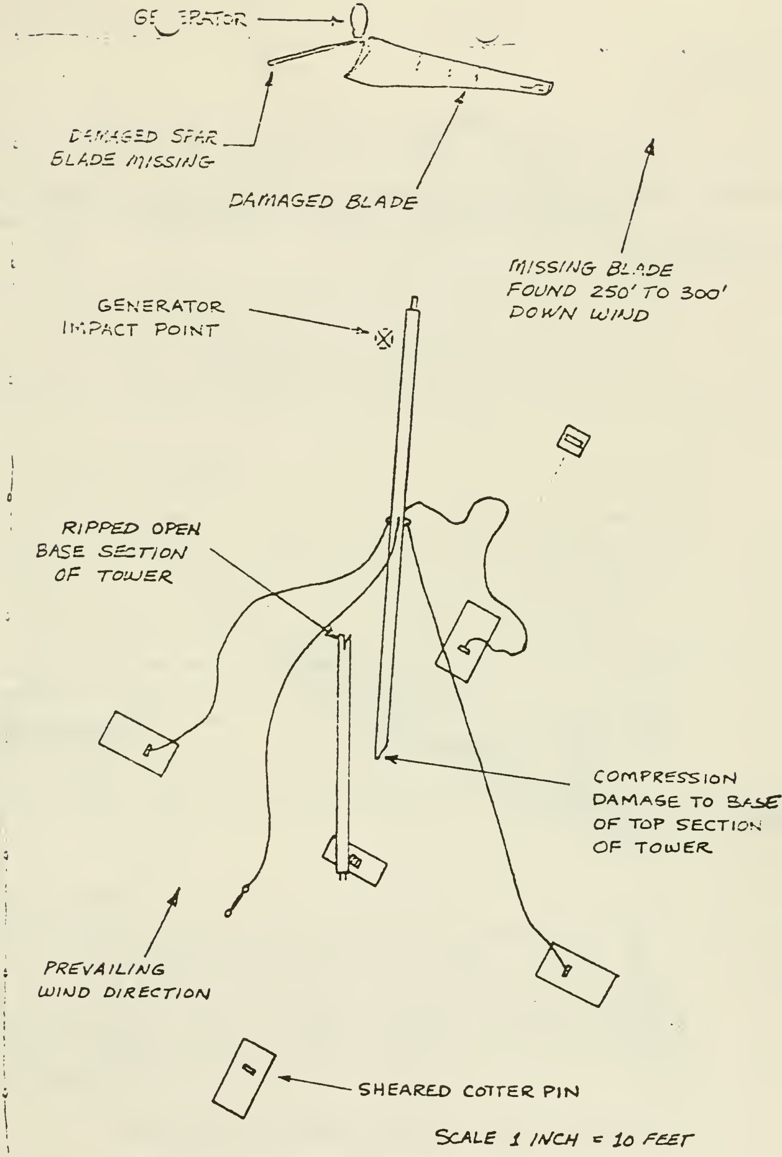


FIGURE 16. NUMBER 4 MACHINE FAILURE: TOWER AND GENERATOR DETAIL

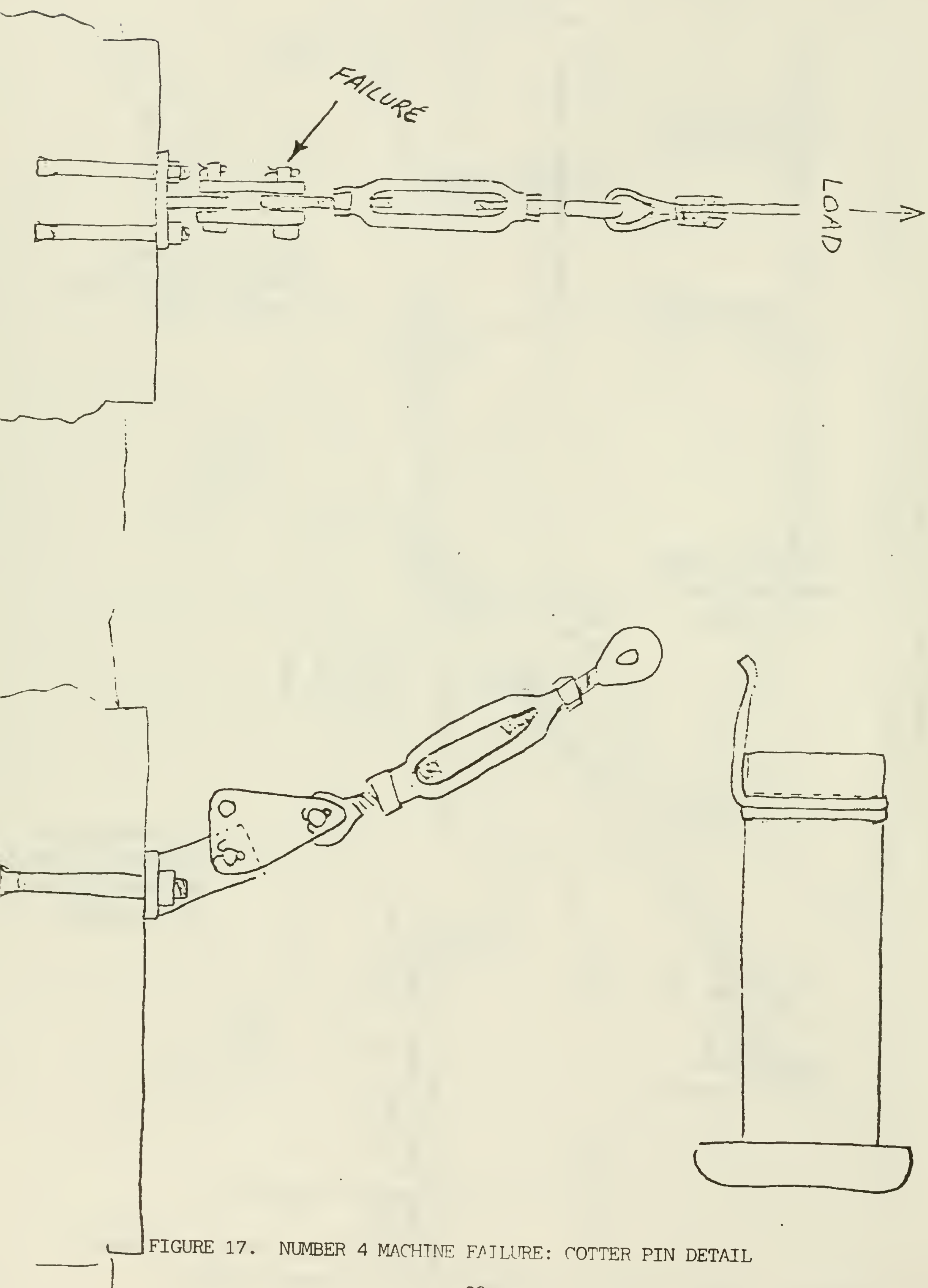


FIGURE 17. NUMBER 4 MACHINE FAILURE: COTTER PIN DETAIL

wind farm to investigate the blade cracking problem. Carter returned to the factory to continue the redesign of the pitch-up mechanism to prevent excessive overspeeds and to modify the blade construction to prevent blade problems.

During the weeks that followed, JCE also discovered a problem with the heat treating method used on the reduction gears used in the wind generators. Cracks in gears had been noted on other machines and had been traced to a change in heat treating. JCE informed MultiTech personnel that all four generators would be replaced in order to avoid changing the faulty gears in the field.

Warranty Repair and Replacement

During the period from April 21 to April 28, 1982 a representative from JCE and an engineer from MultiTech replaced all four wind generators with new modified generators. The blades and the entire generator mechanism was replaced on generators No. 1, 2, and 3. The supporting pole, the electronic control station, and the guy wires were the only major parts not replaced. The entire generator mechanism, the blades, the electronic control station, the tower, and the lead guy wire were replaced on generator No. 4. All components were replaced under warranty at no cost to the city. The ability of the manufacturer's to respond to and make repair of the facility, as per warranty, has been considered commendable; certainly a more reluctant attitude toward the warranty items would have seriously jeopardized the project.

Performance To-Date

On April 28, 1982, the completed wind farm again became operational. All four generators were operating as specified in the original contract. No major problems have arisen since the April 28 start-up date, though a number of smaller problem areas within the internal mechanism have arisen, including the electronic design quality of the control package which monitors performance of the individual units.

On May 12, a scheduled two week inspection was performed on all four wind generators by a representative of MultiTech and four city operating personnel. During this inspection, a training session was conducted by the MultiTech representative for the city operating personnel. During the inspection only minor adjustments were made to the hand brake adjustment mechanism. No significant mechanical or electrical problems were encountered.

However, a problem did appear that has been minor in effect, but has not been solved. During the daily operating inspection performed before the two week inspection on May 12, the No. 2 generator was found to be motoring. When the generator goes into a motoring mode it uses electrical power instead of producing power. The generator was stopped and re-started and then operated properly. The problem has continued for approximately 3½ months, occurring a total of approximately 10 times. JCE is investigating this motoring problem, and claims to have located the cause of the problems and is now designing a modification to the electronic control package to prevent the motoring problem. As soon as this design modification is completed, JCE will send a new electronic control box for the generators displaying this problem. Additionally, apparently improper frequency signals have been received in the control package, interfering with correct monitoring of actual generator performance. This has been reported to JCE who are attempting to correct such.

Another nagging problem with potentially more serious consequences have been lightning strikes. On May 19, a lightning strike on the MPC power line damaged the electronic control box on generators No. 3 and 4. The damaged electronic controls were removed and sent to JCE for repairs. A similar event occurred on June 12, damaging the control box on generator No. 2. Down times on No. 3 and 4 was about a week and about two weeks on No. 2. This problem was considered outside of warranty by JCE and the $600.00 repair bill associated with this problem was covered by the city with $250.00 coming out of wind farm revenue and $350.00 covered by existing insurance on the facility. During the original installation, the generators were provided with lightning protection devices. However, JCE is now recommending the installation of additional lightning protection. The recommended equipment was evaluated by MultiTech, and a positive concurrence was forwarded to the City of Livingston. The additional lightning arrestment equipment carried a tag of approximately $1,000 and, again, had to be covered by wind farm revenue.

Another problem not associated with the machine itself was that of a faulty billing meter. The problem was identified in early January; it was believed that the problem had been corrected, but it re-surfaced in June. The JCE Model 25 machine has a power meter and this is compared to the MPC-installed billing meter. On January 12, it had been discovered that the main kilowatt-hour billing meter installed by MPC was in error, and was not correctly recording the power produced by the wind farm. MPC was notified and the meter was recalibrated by MPC personnel. However, while preparing the May and June monitoring performance report from data collected by the operating personnel, it became apparent that the MPC installed kilowatt-hour main billing meter was once again in error. MPC was informed of this problem and a crew was sent out to check the metering system. They discovered that main kilowatt-hour meter had been wired incorrectly when it was re-installed during early January. An MPC representative assured the city personnel that the metering error has been corrected during the second week of July. Since correction of this particular problem, discrepancies have been still noted between the individual generator meters supplied by the manufacturer and the single utility end meter monitored by MPC. The degree of discrepancy, however, is considered small enough to be attributed to a normal operating margin of error.

V. SUMMARY AND CONCLUSIONS

Hardware Assessment

There have been three mechanical and four electrical problems that affected the amount of power generated and the monetary credits for the power. The problems appear to have been solved although all fixes have not been implemented. These problems have been and are:

Mechanical - Slowness of the pitch-up mechanism
- Cracking of the propeller blades
- Potential failure of reduction gears

Electrical - Incorrect calibration and wiring of the billing meter
- Lightning caused damage to control boxes
- Motoring of the electrical generator
- Control box monitoring of generator operating performance

The first three problem areas, all mechanical, apparently have been fixed; at least, that following a combination of re-design and tightening of quality control procedures, there has not been a reoccurrence.

The billing meter error has hopefully been corrected by the MPC meter crew. MPC is also making a correction payment to the city to reflect the previous incorrect payments.

The problem of lightning strikes on the MPC power line causing damage to the electronic controls should be solved soon, following the installation of additional lightning protection recommended by JCE.

JCE is also redesigning the electronic control package to correct the motoring problem that has been experienced on some of the generators. A review of the performance data indicates that the motoring problem has caused a very minimal increase in the city's electric bill, approximately $8.00 total. Due to the daily inspections being conducted by the city operating personnel, this motoring problem has been kept under control to this point. This same redesign process should also resolve the electronic performance monitoring errors noted earlier, though at the time of this writing these problems remain unresolved.

Pre-Construction Assessment

Other points that may be of interest to anyone starting a wind farm project are the following. The slowest and hardest part of the project are the activities performed prior to contract initiation. During this period, the project is defined, funding is obtained, and pressure builds to start immediately to accommodate conflicting schedules. It all requires much longer than what the planning indicates is reasonable, though as more experience is gained throughout the wind energy industry and field of direct application, these logistical problems will hopefully be reduced or resolved. Wind machine delivery requires more time relative to other equipment. A great many wind machine manufacturers are relatively new companies that may be unfamiliar with bonding requirements and generally also have limited manufacturing capabilities; both these items can induce long delays before power is generated. Additionally, the area of utility purchase agreement, meeting associated pre-conditions and actual utility tie-in require substantial time, effort and resource and should not be underestimated in this regard.

Site Assessment

Another factor that is obvious, but can be planned around, is winter weather in northern latitudes. If planning includes a tight schedule for completion of the project before severe winter weather arrives, or if planning includes a start in early spring, one must be prepared to work in winter-type weather. The installation of machines on this project occurred one-to-two months later than planned and consequently took twice as long as planned during winter storms in mid-December. The cold (naturally the wind chill factor at a wind farm is severe); and the shortness of daylight results in very real and serious working constraints. The Livingston area, fortunately, is one of the milder climatic sites in the region due to the characteristics associated with the nature of the prevailing southwesterly air currents, commonly known as 'chinook winds', which are off the Pacific Ocean. Ambient air temperature associated with these same air currents generally range from 40^{0} - 55^{0} throughout the winter when these same winds are experienced.

Ingress and egress to facility siting requires careful forethought, when considered against the background of seasonal variation in weather conditions, especially inclement conditions. The obvious and previously discussed importance of daily inspections necessitates access to the facility, and must be assured.

Lastly and most importantly, as has been stressed at the beginning of the Final Report, well monitored and data analyzed sites, resulting in site-specific wind energy projections are absolutely required in order to be assured of economic viability, given functioning hardware. The best laid plans, including wind generator selection, utility interface, operation and maintenance support personnel and other areas of concern, are meaningless if improper placement of the wind farm results in low wind generation performance and associated loss of income.

Overall Project Assessment

Pleasant factors in the implementation of this project were the machine manufacturer and the city personnel. Many of the problems that JCE experienced on this project were frustrating and expensive to solve. The thoroughness and responsiveness of JCE were paramount factors in getting the machines running. JCE stood behind their machines, both philosophically and financially. Another vital partner in keeping the wind farm running has been, and continues to be, the city personnel who perform daily checks as well as periodic maintenance checks. Many problems were first found in their daily checks, thereby enabling quick fixes to be made, or further damage prevented. With any equipment, particularly a dynamic piece of equipment such as wind machine, continued successful operation depends on conscientious participation by motivated people, such as the city personnel.

As detailed in the Chart of Accounts; Wind Farm Revenue (Section VI.), the income from electricity sales to-date is approximately $5,000. Costs incurred in hardware replacement and repair costs, reimbursement of city personnel labor (both in personnel and equipment costs) and, finally, ability of the wind farm to contribute to costs incurred in the electrical demand of the waste-water treatment plant (the dedicated recipient facility) have been severely limited in relation to wind farm revenue; as of the time of this writing, obviously the wind farm is operating as a deficit account.

However, the wind farm has been on-line less than one year and cannot be reasonably expected to meet operating costs as well as the sale of electricity to help meet the power bills at the sewage facility. Additionally, the 'de-bugging' of the wind generators and associated 'down-time' have further limited the ability of the wind farm to generate substantial income within the first year of operation; hopefully, this phase of the project is reaching conclusion.

The ability of the facility sponsor and owner, in this case the City of Livingston, to have the financial resources, and personnel and equipment capabilities to meet the on-going needs of operating the facility while absorbing front-end, short-term financial losses is paramount to successful wind energy application at this point in time. Obviously the grant funding provided by the State of Montana in covering purchase, construction and engineering costs, as well as earlier wind monitoring and data collection by the Montana DNRC and U.S. DOE have made this project feasible. Without this assistance, this project would not have materialized; it is through the joint-venturing of this nation's first municipal wind energy facility -- state and federal grants coupled with municipal resources and stamina -- that ultimate success in operation of the wind farm can be realized.

Further, as buy-back rates continue to escalate in relation to fossil fuel avoided costs; hardware costs in both terms of purchase and operation line-items drop through experience and mass-manufacturing capabilities; and groups with existing state and federal tax liabilities participate in utilization of this kind of electrical generating power facilities and avail themselves of available tax credits (front-end tax sheltering coupled with prospects for long-term yield on the investment) associated with investment in alternative energy application, and power sales through wind farm systems, that wind energy in general will prove viable and successful.

VI. CHART OF ACCOUNTS

WIND FARM GRANT

City Account No. 2547.22

Breakdown of Grant Expenditures

$101,010.00	Jay Carter Enterprises (wind turbines)
70,367.00	MultiTech, Inc. (Engineering/Initial Supervision)
27,000.00	Taylor Construction Co. (Site Preparation)
12,623.00	Montana Power Company (Powerline Upgrade)
10,000.00	City of Livingston (Administration)
1,000.00	U.S. Environmental Protection Agency (Match for Environmental Assessment)
$222,000.00	TOTAL PROJECT EXPENDITURES
$222,000.00	TOTAL GRANT FUNDS PROVIDED
$ 0	BALANCE OF FUNDS

WIND FARM ELECTRIC REVENUE AND EXPENSES

Summary

The following tables detail revenue realized through sale of electricity from the Livingston Wind Farm to MPC, and expenses incurred in operation and maintenance of the same facility.

In summary, $5,066.74 has been credited to the account through October 1982, while $14,883.89 has been entered against the account, inclusive of all reimbursable expenditures through November. A debit balance of $9,817.15 remains to be reimbursed the City of Livingston for expenses to-date, from future sales of electricity. These same accounts will continue to be tracked into the future, to be able to determine if and when the State of Montana will receive actual return on the grant investment as per DNRC Contract RAE 241-811, Appendix B, Section III: Excess Energy Payback.

WIND FARM REVENUE: SALE OF ELECTRICITY

City Account Number 5734.31

12/22/81 - 1/7/82	$ 252.42
4/23/82 - 4/30/82	252.32
5/1/82 - 5/31/82	330.85
6/1/82 - 6/30/82	877.44
Sub-Total (FY 81-82)	$ 1713.03

7/1/82 - 7/31/82	$ 707.79
8/1/82 - 8/31/82	619.31
9/1/82 - 9/30/82	823.98
10/1/82 - 10/31/82	1202.63
Sub-Total (To-Date - FY 82-83)	$ 3353.71
TOTAL	$ 5066.74

WIND FARM EXPENSES: UTILITIES AND REPAIRS

City Account Numbers 5843.23 and 5743.34

2/8/82	MPC Electricity Purchase	$ 3.74	
3/22/82	MPC Electricity Purchase	1.87	
4/9/82	MPC Electricity Purchase	1.87	
5/4/82	Jerry's Hardware Hank (Hardware)	5.29	
5/13/82	MPC Electricity Purchase	1.87	
6/11/82	MPC Electricity Purchase	21.43	
6/13/82	Champion Auto (Hardware)	7.98	
6/14/82	Bair Electric (Fuses)	8.00	
6/30/82	City Treasurer (Postage)	47.56	
7/20/82	City Treasurer (Postage)	23.78	
7/23/82	Carter Wind Systems (Lightning damage to control packages	600.00	(-$350.00 United Agency Ins. coverage)
8/5/82	United Agency Ins. Payment	1280.00	(FY 82-83)
8/12/82	Chaney's Hardware (Misc. materials)	6.14	
8/12/82	Volk Electric (Elec. Hardware)	5.16	
9/7/82	MPC Electricity Purchase	6.47	
9/8/82	MPC Electricity Purchase	37.89	
10/7/82	Jerry's Hardware Hank (Tools)	109.70	
10/11/82	MPC Electricity Purchase	11.48	
10/11/82	Postage	10.47	
10/13/82	Strong & Bradley (Hardware)	25.58	
10/13/82	Coast to Coast (Hardware)	13.82	
11/5/82	MPC Electricity Purchase	1.87	
11/5/82	Strong & Bradley (Hardware)	6.60	
11/18/82	Agrineeds (Hardware)	7.20	
11/30/82	Alpine Electronics (Meter)	39.95	
12/6/82	Carter Wind Systems (Control Package)	1200.00	
12/6/82	Carter Wind Systems (Meter)	300.00	
TOTAL (To-Date)		$3435.72	

WIND FARM EXPENSES: MAINTENANCE

City Account Number 5743.23

Month/Year	Labor*		Equipment**	
April 1982	32 hours:	$ 264.00	1 Vehicle:	$ 15.00
May 1982	115½ hours:	952.88	2 Vehicles:	30.00
June 1982	64 hours:	528.00	No Vehicles:	
July 1982	62 hours:	511.50	No Vehicles:	
August 1982	86 hours:	709.50	1 Vehicle:	15.00
September 1982	85 hours:	701.25	3 Vehicles:	45.00
October 1982	89 hours:	734.25	3 Vehicles:	45.00
November 1982	168 hours:	1386.00	7 Vehicles:	105.00
Sub-Total		$5787.38		$255.00

TOTAL $6042.38

*Labor - figured at $8.25 per hour

**Equipment - figured at $15.00 per hour

WIND FARM EXPENSES: SEWAGE TREATMENT PLANT POWER BILL

City Account Numbers 5743.75 and 5343.35

6/2/81 - 6/26/81	$ 349.80
6/26/81 - 7/29/81	266.10
7/29/81 - 8/28/81	297.93
8/28/81 - 9/30/81	321.22
9/30/81 - 10/29/81	374.77
10/29/81 - 12/1/81	663.41
12/1/81 - 1/1/82	1341.81
SUB TOTAL	$ 3615.04
1/1/82 - 2/7/82	$ 1693.84
2/7/82 - 3/1/82	1702.84
3/1/82 - 3/31/82	1967.24
3/31/82 - 5/1/82	1478.95
5/1/82 - 6/2/82	1720.86
6/2/82 - 7/2/82	1283.60
7/2/82 - 8/2/82	905.22
8/2/82 - 8/27/82	1077.51
SUB TOTAL	$11830.06
TOTAL (FY 81-82 To-Date)	$15445.10

Wind Farm dedicated share @ 35% of total power demand of sewage treatment plant (as per DNRC contract)

$15445.10 x .35 = $5405.79

TOTAL REIMBURSEABLE EXPENSE $5405.79

VII. PROJECT SPINOFFS

Public Access

The Livingston Wind Farm has undoubtedly received, proportionately, the widest public exposure of the Renewable Energy Projects of the Montana DNRC funded to-date. Approximately some fifty (50) separate tours on, and presentations of, the wind energy system have been made to-date, involving directly over 2,000 people in Montana and beyond in education of application of alternative energy resources.

The placement of the wind farm on a site immediately adjacent to U.S. Interstate Highway 90 has achieved, and continues to insure, constant public exposure, again in an unprecendented nature.

Media Exposure

Additionally, media exposure of the municipal facility has been phenomenal, encompassing local and regional radio, T.V., newspaper and magazine coverage, including MTN T.V. Network, the A.M. Intermountain News Network, A.P. and U.P.I. News Wire Services. Also, coverage has included such nationwide circulation as the Wall Street Journal, Knight-Ridder News Chain, Philadelphia Enquirer, Time Magazine, American Public Power Magazine, Canada's Renewable Energy News and a host of other media outlets.

Commercialization Potential

Indirect spinoffs of the Livingston Wind Energy System Project have included the wind farm as a "trial balloon" for and attraction to various national and international business and development firms, to consider Montana for private sector development of this inexhaustible energy source. In this regard, three (3) local trained mechanics have been placed in permanent job slots associated with the burgeoning local wind industry, through relocation of Windpowered Machines, Ltd. of Chicago, Illinois. Eight (8) city employees have received in-depth training in this area, broadening the base of local related skills. The Livingston Job Service reports have over one hundred (100) applications pending for placement specifically in wind energy oriented future job opportunities. The expressed interest of diverse groups including Bendix Corporation and myriad development and financing concerns give expression to the future potential for capitalization of this energy resource.

The attached list documents representative tours and presentations made of the Livingston Wind Farm; this kind of public exposure to this facility is anticipated to increase, in part, through a thorough and thoughtful presentation format involving handouts, slide materials, and actual 'hands-on' tours to effectively stimulate such interest.

WIND FARM ON-SITE TOURS AND PRESENTATIONS

9/21/81	DOE/BPA Presentation; Missoula, MT
1/8/82	Montana Power Company
1/11/82	Dept. of Natural Resources & Conservation
1/14/82	KXLF-TV
2/2/82	Springdale, MT; 4-H Club
2/13/82	Montana Jaycee's Presentation; Cut Bank, MT
2/26/82	Montana State University; College of Agriculture
3/5/82	PanAero Corp. & MERDI
3/15/82	Professional Associates - Partnership
3/31/82	Graduate Research Project; Montana State University
4/5/82	University of Missouri, Columbia @ Kansas City, MO
4/13/82	Time Magazine
4/14/82	Wall Street Journal
4/15/82	Unique Investments - Partnership & MERDI
4/21/82	BLM, Butte Division
4/30/82	Bendix Corp. & Enertech Corp.
5/4/82	Windpowered Machines, Ltd. - Partnership
5/7/82	Colo. Council of Local Energy Officials; Denver, CO
5/10/82	Vice-President for Research, MSU & Physics Dept., MSU
5/11/82	KTVQ-TV
5/14/82	Physics Coll., MSU; Bozeman, MT
6/1/82	Livingston School Districts
6/3/82	Montana Association of Planners
7/2/82	MSU School of Engineering/Montana Power Company
7/12/82	Western Energy Magazine
7/24/82	Black Hawk Assoc.
8/2/82	Rotary; Livingston, MT
8/3/82	Kiwanas; Livingston, MT
8/6/82	ALCOA Corp.
8/23/82	Montana Highway Department
8/24/82	MSU, Extension Cooperative Service
8/26/82	MSU, Extension Cooperative Service
9/8/82	Bozeman Chamber of Commerce

9/27/82	President Tietz & Mr. Johns, Chairman of Endowment Foundation; MSU
9/28/82	Montana Cowbelle's Association
9/30/82	American Public Power Association
10/7/82	Wind Energy Specialities
10/18/82	MSU, College of Agriculture (Agric. Engineering)
10/25/82	AWEA National Conference; Amarillo, TX
11/1/82	Industry Design Laboratories Corp.
11/15/82	Bozeman Exchange Club; Bozeman, MT
11/19/82	Dept. of Natural Resources & Conservation
11/19/82	MSU Undergraduate Physics Club
12/2/82	United Technologies Corp./GENRO/PSC

VIII. MONTHLY PERFORMANCE REPORTS

January - October 1982

MONTHLY PERFORMANCE MONITORING REPORT

Date: 2/24/82
Period: 1/1/82 to 1/31/82

Project Title: Performance Monitoring of Livingston Wind Farm

Contract:

Start: 12/22/81
Completion Date: 2/28/83
Contractor: MultiTech, Inc.
P.O. Box 4078
Butte, Montana 59702

1.0 Contract Objective

The objectives of this contract are to evaluate the performance, reliability, and income of the Livingston Wind Farm based on the data supplied by City of Livingston operating personnel.

2.0 Contract Tasks

Task 1 - Performance Evaluation

The performance evaluation will consist of an evaluation of each wind generator as well as an evaluation of the performance of the entire wind farm. The evaluations will include an operating history of each wind generator, the power produced by each wind generator, the average power produced per hour of operation for each generator, and a survey of the power produced according to the average wind speed.

Task 2 - Reliability Evaluation

Each wind generator's reliability will be evaluated according to the maintenance required and the down time experienced during the evaluation period.

Task 3 - Income Evaluation

The monetary income of the wind farm will be evaluated according to billing information supplied by the City of Livingston.

3.0 Performance Evaluation

3.1 Operating History

Wind generator No. 4 was erected and started on December 22, 1981. Wind generators Nos. 1, 2, and 3 were erected and started on December 23, 1981. Wind generators Nos. 1, 2, and 3 were automatically shut down by their out-of-balance brakes on December 25, 1981. On December 28 generators Nos. 1, 2, and 3 were lowered, their out-of-balance brakes reset, then they were raised and restarted.

Again on December 31, 1981, wind generators Nos. 1, 2, and 3 were automatically shut down by their out-of-balance brakes. This time these three generators were left out of operation pending a scheduled two week inspection scheduled for January 7, 1982. Wind generator No. 4 was still operating without problems.

On January 7, 1982 wind generator No. 4 experienced a catastrophic failure and was completely destroyed. The other three generators were left standing with their out-of-balance brakes on, pending a failure investigation of generator No. 4.

On January 26, it was discovered that the blades on generators Nos. 1, 2, and 3 were beginning to crack. This initiated a second failure investigation.

The manufacturer (Jay Carter Enterprises) had agreed to replace the blades on generators No. 1, 2, and 3 and also to replace the entire generator No. 4. The manufacturer's latest schedule for the replacement is during the first part of April.

During the month of January, the main billing kilowatt-hour meters installed by the Montana Power Company were found to be in error. MPC was informed of the inaccuracy of the meters and they were repaired. However, the main billing meters were ignored for the monthly billing. The monthly billing reading was taken from the kilowatt-hour meters installed at each generator.

3.2 Performance

The performance chart presents the performance figures for the last week of December 1981 and January 1982. It must be remembered that generators Nos. 1, 2, and 3 operated only during the last week of December and generator No. 4 was destroyed on January 7, 1982.

The average wind speed data was not collected for the period covered by this report. Therefore, the electric power production according to the average wind speed, cannot be calculated for this period.

4.0 Reliability Evaluation

During the period from December 22 to January 31, the out-of-balance brakes on generators Nos. 1, 2, and 3 were each reset twice. The City operating personnel expended approximately 12 man-hours on the brake reset operations.

A scheduled two week inspection of each generator was not carried out because of the failure of generator No. 4 on the same day as the inspection. This inspection will be performed by the manufacturer during the generator replacement and modification procedures scheduled for early in April.

Because of the blade cracking problems on generators Nos. 1, 2, and 3, and the catastrophic failure of generator No. 4, the reliability of the wind generators cannot be evaluated properly at this time. These failures have not occured at other installations.

5.0 Income Evaluation

The total electrical power produced by the wind farm and delivered to the Montana Power Company was 7,562 kilowatt-hours. The City of Livingston billed MPC for this power at a rate of $0.025 per kilowatt-hour. MPC payed the City of Livingston for this power at the actual rate of $0.025142 per kilowatt-hour. The payment was $190.12 for this first billing period.

Paul A Laird by DPMiller

Paul A. Laird, Project Engineer

PERFORMANCE CHART

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	1455	1449	1232	3426	7562
Hours of Operation	102.4	114.4	107.9	265.5	265.5
Hours On-Line	314.6	332.1	332.1	403.6	403.6
Average Hourly KwHrs Output	14.2	12.6	11.4	12.9	28.5

MONTHLY PERFORMANCE MONITORING REPORT

Date: 2/24/82
Period: 2/1/82 to 2/28/82

Project Title:	Performance Monitoring of Livingston Wind Farm
Contract:	
Start:	12/22/82
Completion Date:	2/28/83
Contractor:	MultiTech, Inc. P.O. Box 4078 Butte, Montana 59702

1.0 Contract Objective

The objectives of this contract are to evaluate the performance, reliability, and income of the Livingston Wind Farm based on the data supplied by City of Livingston operating personnel.

2.0 Contract Tasks

Task 1 - Performance Evaluation

The performance evaluation will consist of an evaluation of each wind generator as well as an evaluation of the performance of the entire wind farm. The evaluations will include an operating history of each wind generator, the power produced by each wind generator, the average power produced per hour of operation for each generator, and a survey of the power produced according to the average wind speed.

Task 2 - Reliability Evaluation

Each wind generator's reliability will be evaluated according to the maintenance required and the down time experienced during the evaluation period.

Task 3 - Income Evaluation

The monetary income of the wind farm will be evaluated according to billing information supplied by the City of Livingston.

3.0 Performance Evaluation

4.0 Reliability Evaluation

5.0 Income Evaluation

Due to the fact that the wind farm did not operate during the month of February, and no data was available for this period, there is no performance evaluation, reliability evaluation, or income evaluation available for this reporting period.

Paul A Laird by D Miller

Paul A. Laird, Project Engineer

MONTHLY PERFORMANCE MONITORING REPORT

Date: 4/5/82
Period: 3/1/82 to 3/31/82

Project Title:	Performance Monitoring of Livingston Wind Farm
Contract:	
Start:	12/22/82
Completion Date:	2/28/83
Contractor:	MultiTech, Inc. P.O. Box 4078 Butte, Montana 59702

1.0 Contract Objective

The objectives of this contract are to evaluate the performance, reliability, and income of the Livingston Wind Farm based on the data supplied by City of Livingston operating personnel.

2.0 Contract Tasks

Task 1 - Performance Evaluation

The performance evaluation will consist of an evaluation of each wind generator as well as an evaluation of the performance of the entire wind farm. The evaluations will include an operating history of each wind generator, the power produced by each wind generator, the average power produced per hour of operation for each generator, and a survey of the power produced according to the average wind speed.

Task 2 - Reliability Evaluation

Each wind generator's reliability will be evaluated according to the maintenance required and the down time experienced during the evaluation period.

Task 3 - Income Evaluation

The monetary income of the wind farm will be evaluated according to billing information supplied by the City of Livingston.

3.0 Performance Evaluation

4.0 Reliability Evaluation

5.0 Income Evaluation

Due to the fact that the wind farm did not operate during the month of March, and no data was available for this period, there is no performance evaluation, reliability evaluation, or income evaluation available for this reporting period.

Paul A. Laird

Paul A. Laird, Project Engineer

MONTHLY PERFORMANCE MONITORING REPORT

Date: 6/1/82
Period: 5/1/82 to 5/21/82

Project Title:	Performance Monitoring of Livingston Wind Farm
Contract:	
Start:	12/22/82
Completion Date:	2/28/83
Contractor:	MultiTech, Inc. P.O. Box 4078 Butte, Montana 59702

1.0 Contract Objective

The objectives of this contract are to evaluate the performance, reliability, and income of the Livingston Wind Farm based on the data supplied by City of Livingston operating personnel.

2.0 Contract Tasks

Task 1 - Performance Evaluation

The performance evaluation will consist of an evaluation of each wind generator as well as an evaluation of the performance of the entire wind farm. The evaluations will include an operating history of each wind generator, the power produced by each wind generator, the average power produced per hour of operation for each generator, and a survey of the power produced according to the average wind speed.

Task 2 - Reliability Evaluation

Each wind generator's reliability will be evaluated according to the maintenance required and the down time experienced during the evaluation period.

Task 3 - Income Evaluation

The monetary income of the wind farm will be evaluated according to billing information supplied by the City of Livingston.

3.0 Performance Evaluation

3.1 Operating History

On May 12, 1982, a scheduled two week inspection was performed on all four wind turbines by Paul Laird of MultiTech and four City of Livingston operating personnel. Each of the wind generators were lowered and inspected, following the procedures outlined in the Jay Carter Enterprises maintenance manual.

On May 17 wind generator No. 2 was found motoring during the daily inspection. The wind generator was stopped and restarted and then operated properly. Jay Carter was informed of this problem, and is working on a fix for this problem.

On May 19 wind generator No. 1 was found motoring during the daily inspection. The wind generator was stopped and restarted and then operated properly. When the generator is in the motoring mode, it runs as a motor and uses electric power.

On May 19 wind generators Nos. 3, and 4 sustained damage to their electronic controls at the base of the tower during an electrical storm. The lightning strike was apparently located somewhere on the Montana Power Company's transmission lines. The electronics package has been removed from both generators and was sent to Jay Carter Enterprises for repair. Generators Nos. 3 and 4 have been out of service since May 19, 1982.

3.2 Performance Monitoring

The attached performance chart presents the performance figures for the first three weeks of May. The performance chart shows the average wind speed compared to the average power produced for the first time. The average wind speed could only be calcuated for the period from May 12 to May 19, because of the available data; therefore this average wind speed was compared to the average power for the same period.

4.0 Reliability Evaluation

Wind generators Nos. 1 and 2 both experienced a motoring problem during this reporting period. This problem caused very little lose of power production due to the daily inspections being performed by City of Livingston maintenance personnel. This fact, emphasizes the importance of the daily inspections.

The motoring problem is being studied by the manufacturer, Jay Carter Enterprises, and hopefully will be solved in the near future.

The lightning strike on the Montana Power Company transmission line, that caused the electronic package failure on generators Nos. 3 and 4 is also being studied by the generator manufacturer. It is expected that Jay Cater Enterprises will also design and recommend additional lightning protection for the wind generator units.

5.0 Income Evaluation

The total electrical power produced by the wind farm, as recorded by the kilowatt-hour meters installed at the wind generators was 9890 kWhrs. However, the Montana Power Company main kilowatt-hour billing meter recorded only 2976 kilowatt-hours. This large discrepancy should be investigated and corrected as soon as possible, for billing accuracy. The errors involved could cost the City of Livingston a great deal of lost income.

No billing information was received for this May report, and therefore the income evaluation cannot be completed for this reporting period.

Paul A. Laird

Paul A. Laird, Project Engineer

PERFORMANCE CHART

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	2482	2618	2390	2400	9890
Hours of Operation	260.6	310.2	252.2	249.4	310.2
Hours On-Line	494.5	493.8	433.0	448.1	494.5
Average Output at Average Wind Speed (mph)	1.7/7.2	1.8/7.5	1.3/6.5	N/A	6.4/7.1

May 1982

MONTHLY PERFORMANCE MONITORING REPORT

Date: 6/1/82
Period: 4/1/82 to 4/30/82

Project Title:	Performance Monitoring of Livingston Wind Farm
Contract:	
Start:	12/22/82
Completion Date:	2/28/83
Contractor:	MultiTech, Inc. P.O. Box 4078 Butte, Montana 59702

1.0 Contract Objective

The objectives of this contract are to evaluate the performance, reliability, and income of the Livingston Wind Farm based on the data supplied by City of Livingston operating personnel.

2.0 Contract Tasks

Task 1 - Performance Evaluation

The performance evaluation will consist of an evaluation of each wind generator as well as an evaluation of the performance of the entire wind farm. The evaluations will include an operating history of each wind generator, the power produced by each wind generator, the average power produced per hour of operation for each generator, and a survey of the power produced according to the average wind speed.

Task 2 - Reliability Evaluation

Each wind generator's reliability will be evaluated according to the maintenance required and the down time experienced during the evaluation period.

Task 3 - Income Evaluation

The monetary income of the wind farm will be evaluated according to billing information supplied by the City of Livingston.

3.0 Performance Evaluation

3.1 Operating History

The wind farm has not operated since January 7, 1982, due to failures experienced on that date. During the period from April 18 to April 28, 1982 all four wind generators were repaired or replaced by G. W. Chisholm of Jay Carter Enterprises and Paul Laird of MultiTech.

Generators Nos. 1, 2, and 3 had experienced blade cracking during January. Each of these three generators were made operational by replacing the entire generator/gearbox/blade unit at the top of the tower. The original towers were modified so that they could be pressed together with a greater force than that used during the original installation. The replacement blades were structurally strengthened by the addition of a more dense foam core and added fiberglass skin thickenss. All blade internal mechanical parts were modified for added strength and reliability. The only parts reused on generator units Nos. 1, 2, and 3 were the tower and electrical control unit at the tower base.

Generator No. 4 had been completely destroyed on January 7, 1982, due to a blade failure and complete collapse of the generator unit. This generator unit was entirely replaced, including the generator, gearbox, blades, tower, lead guy wire, and electrical control unit at the tower base.

Generator No. 1 was erected and started at 1:00 p.m. on April 24; generator No. 2 was started at 1:45 p.m. on April 25; generator No. 3 was started at 12:00 noon on April 26; and generator No. 4 was started at 9:45 a.m. on April 28.

3.2 Performance

The attached performance chart presents the performance figures for the last few days of April 1982.

The average wind speed data was not collected for the period covered by this report. Therefore, the electric power production according to the average wind speed cannot be calculated for this period.

4.0 Reliability Evaluation

During the period from April 24 to April 30, generators Nos. 1, 2, 3, and 4 operated without any problems. Each generator's actual start-up time and date were stated earlier in the section on Operating History.

A scheduled two week inspection of each generator was tentatively scheduled for May 12, 1982.

The reliability of the wind generators for this short period in April was very good, as expected.

5.0 Income Evaluation

The total electrical power produced by the wind farm and delivered to the Montana Power Company was 3,127 kilowatt-hours. No billing information was received for this April report and it is assumed that the City of Livingston did not bill the Montana Power Company due to the short operating period during April.

NOTE: The total electrical power produced by the wind farm, as recorded by the kilowatt-hour meters installed at the wind generators is 3,127 kWhrs. However, the Montana Power Company main kilowatt-hour billing meter recorded only 2,208 kWhrs.

The Montana Power Company main kilowatt-hour billing meter was found to be inaccurate once before, during the December-January billing period. This discrepancy should be investigated and corrected as soon as possible, for billing accuracy.

Paul A. Laird

Paul A. Laird, Project Engineer

PERFORMANCE CHART

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	1013	822	725	567	3127
Hours of Operation	91.4	73.5	63.5	42.6	91.4
Hours On-Line	143.6	120.2	97.9	53.2	143.6
Average Hourly KwHrs Output	11.1	11.2	11.4	13.3	34.2

April 1982

MONTHLY PERFORMANCE MONITORING REPORT

Date: 7/9/82
Period: 5/22/82 to 6/30/82

Project Title: Performance Monitoring of Livingston Wind Farm

Contract:

Start: 12/22/81
Completion Date: 2/28/83
Contractor: MultiTech, Inc.
P.O. Box 4078
Butte, Montana 59702

1.0 Contract Objective

The objectives of this contract are to evaluate the performance, reliability, and income of the Livingston Wind Farm based on the data supplied by City of Livingston operating personnel.

2.0 Contract Tasks

Task 1 - Performance Evaluation

The performance evaluation will consist of an evaluation of the performance of each wind generator as well as an evaluation of the performance of the entire wind farm. The evaluations will include an operating history of each wind generator, the power produced by each wind generator, the average power produced per hour of operation for each generator, and a survey of the power produced according to the average wind speed.

Task 2 - Reliability Evaluation

Each wind generator's reliability will be evaluated according to the maintenance required and the down time experienced during the evaluation period.

Task 3 - Income Evaluation

The monetary income of the wind farm will be evaluated according to billing information supplied by the City of Livingston.

3.0 Performance Evaluation

3.1 Operating History

On May 26, 1982, the repaired electronic control box was installed in the control panel of generator No. 3. The wind generator was then re-started and placed back in operation. Generator No. 3 had been out of service for seven days.

On May 27 the repaired electronic control box was installed in the control panel of generator No. 4. The wind generator was then re-started and placed back in operation. Generator No. 4 had been out of service for eight days.

On June 12 a lightning strike on the Montana Power Company's (MPC) power line damaged the electronic control box on generator No. 2. On June 13 the damaged electronic control box was removed from generator No. 2 and sent to Carter Wind Systems for repair.

On June 14 a good electronic control box was removed from generator No. 1 and installed in the control panel of generator No. 2. Generator No. 2 was then started and placed back on line. Generator No. 1 was shut down and taken out of service. This control box switch was completed to take advantage of the higher wind speed that are seen by generator No. 2. This practice of switching control parts is not recommended in the future, as it is not cost effective. The labor involved in this control swapping costs more than the small gain in electric power production.

On June 23 generator No. 2 was found motoring during the daily inspection. The generator was stopped and then re-started and then performed properly.

On June 25 the repaired electronic control box was installed in generator No. 1. Generator No. 1 was then re-started and placed back in service.

On June 27 generator No. 2 was observed operating in an apparent over-speed condition. This diagnosis may not have been correct, however the electric power produced by generator No. 2 on that date was very low. The generator was stopped and then restarted, and then operated properly.

3.2 Performance Monitoring

The attached performance chart presents the performance figures for the last ten days of May and also for the entire month of June. These periods were separated in order to present the June figures for one full month.

4.0 Reliability Evaluation

Wind generator No. 2 experienced a motoring problem once during this reporting period. This problem caused very little loss of power production due to the daily inspections being performed by City of Livingston maintenance personnel. This fact emphasizes the importance of the daily inspections.

During a telephone conversation with Jay Carter Jr. of Carter Wind Systems (CWS), Jay indicated that he is working on a solution to the motoring problem. He claims that he has found a fault in the electronic control design and that he is re-designing the control system to prevent the motoring problem. He said that the modified control package will be installed in the faulty generators as soon as the new electronics are completed.

The electronic control box on wind generator No. 2 was damaged during this reporting period by a lightning strike on the MPC transmission line. Jay Carter, Jr. has recommended the installation of additional lightning protection to avoid this problem in the future. The recommended lightning protection is being evaluated by the Engineering Department at MultiTech at this time. A recommendation for this added lightning protection will be forwarded to the City of Livingston as soon as this evaluation is completed.

5.0 Income Evaluation

The total electrical power produced by the wind farm, as recorded for the last ten days of May by the kilowatt-hour meters installed at the wind generators was 2901 kWhrs. However, the MPC's main kilowatt-hour billing meter recorded only 960 kWhrs.

The total electrical power produced by the wind farm as recorded for the month of June by the kilowatt-hour meters installed at the wind generators was 8657 kWhrs. However, the MPC's mail kilowatt-hour billing meter recorded only 2400 kWhrs.

At the time of this writing, MPC personnel have corrected their inaccurate billing meter. Therefore, this large discrepancy in the kilowatt-hour readings should be corrected by the end of July.

It is the understanding of the Engineering Department of MultiTech that MPC is in the process of crediting the City of Livingston with an extra 20,600 kilowatt-hours for the period of April 23 to July 1, 1982. This credit should bring added revenue of $824.00 to the City at a rate of $0.04/kWhr.

Paul A. Laird

Paul A. Laird, Project Engineer

PERFORMANCE CHART

May 22 through May 31

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	844	914	612	531	2901
Hours of Operation	97.1	117.0	63.8	59.5	117.0
Hours On-Line	214.3	214.3	114.5	95.2	214.3
Average Hourly kWhrs Output	3.9	4.3	5.3	5.6	13.5

June

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	1555	2285	2423	2394	8657
Hours of Operation	180.3	353.9	328.0	369.5	369.5
Hours On-Line	454.7	695.4	719.3	719.6	719.6
Average Hourly kWhrs Output	3.4	3.3	3.4	3.3	12.0

MONTHLY PERFORMANCE MONITORING REPORT

Date: 9/10/82
Period: 7/1/82 to 7/31/82

Project Title:	Performance Monitoring of Livingston Wind Farm
Start:	12/22/81
Completion Date:	2/28/83
Contractor:	MultiTech, Inc. P.O. Box 4078 Butte, Montana 59702

1.0 Contract Objectives

The objectives of this contract are to evaluate the performance, reliability, and income of the Livingston Wind Farm based on the data supplied by City of Livingston operating personnel.

2.0 Contract Tasks

Task 1 - Performance Evaluation

The performance evaluation will consist of an evaluation of the performance of each wind generator as well as an evaluation of the performance of the entire wind farm. The evaluations will include an operating history of each wind generator, the power produced by each wind generator, the average power produced per hour of operation for each generator, and a survey of the power produced according to the average wind speed.

Task 2 - Reliability Evaluation

Each wind generator's reliability will be evaluated according to the maintenance required and the down time experienced during the evaluation period.

Task 3 - Income Evaluation

The monetary income of the wind farm will be evaluated according to billing information supplied by the City of Livingston.

3.0 Performance Evaluation

3.1 Operating History

On July 8, 1982 generator No. 2 was found motoring during the daily inspection. The generator was stopped and re-started, and then performed properly.

The daily performance log data indicates that this motoring incident accounted for a generated power loss of 17 kilowatt-hours that could have been produced. This loss in monetary terms amounted to 93¢.

On July 14 the wind farm operator reported that generator No. 2 went into an overspeed condition and shut itself down. The generator then re-started itself and continued operating. This occurrence could be due to a power failure on the Montana Power Company transmission lines. The overspeed shutdown is a normal occurrence when the electric power fails on the transmission line.

On July 26 generator No. 3 was found motoring during the daily inspection. The generator was shut down and re-started, and then operated properly.

The daily performance log data indicates no electric power was lost due to this motoring incident.

On July 27 generator No. 3 was found motoring during the daily inspection. The generator was shut down and when the re-start was attempted the electronic control package was damaged. The electronic control package was jumpered on July 28 on instructions from Mike Baird at Carter Wind Systems. This jumper allowed the generator to be put back in service until the new electronic package would arrive from Carter Wind Systems. One day of operation for generator No. 3 was lost due to this electronic failure. The daily performance log data indicates that this incident accounted for a generated power loss of 100 kilowatt-hours, that could have been produced. This loss in monetary terms amounted to $5.33.

3.2 Performance Monitoring

The attached performance chart presents the performance figures for the entire month of July.

The average wind speed for the month of July was above the normal average, and the wind generators performed extremely well. The electrical power output from the wind farm was far above the estimated output for July.

4.0 Reliability Evaluation

Wind generator No. 2 experienced a motoring problem once during this reporting period. Wind generator No. 3 experienced a motoring problem twice during this reporting period. This motoring problem caused very little loss of power production due to the daily inspections being performed by the City of Livingston maintenance personnel.

Wind generator No. 3 also experienced a burned-up electrical control package. This failure caused generator No. 3 to be out of operation one full day. However, due to the timely response of the maintenance crew, this down time was kept to a minimum. The down time for the wind farm for the month of July was less than 1%.

5.0 Income Evaluation

The total electrical power produced by the wind farm, as recorded by the kilowatt-hour meters installed at the wind generators, was 12,238 kWhs. The MPC main kilowatt-hour billing meter recorded 11,712 kWhs. The discrepancy of 512 kWhs shows an error of 4.3%. This small discrepancy between the City's kilowatt-hour meters and the MPC kilowatt-hour meter is within acceptable limits.

The income from the wind farm for the month of July should be approximately $624.25 for power produced at $0.0533/kWh, plus a capacity payment of $128.83 figures at $0.011/kWh. This would be a total income for July of $753.08.

Paul A. Laird

Paul A. Laird, Project Engineer

PERFORMANCE CHART

JULY 1982

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	3034	3130	3024	3050	12,238
Hours of Operation	335.4	389.9	376.0	417.0	417.0
Hours On-Line	744.0	743.8	714.1	743.7	744.0
Average Hourly kWhrs Output	4.1	4.2	4.2	4.1	16.4

MONTHLY PERFORMANCE MONITORING REPORT

Date: 9/13/82
Period: 8/1/82 to 8/31/82

Project Title:	Performance Monitoring of Livingston Wind Farm
Start:	12/22/81
Completion Date:	2/28/83
Contractor:	MultiTech, Inc. P.O. Box 4078 Butte, Montana 59702

1.0 Contract Objectives

The objectives of this contract are to evaluate the performance, reliability, and income of the Livingston Wind Farm based on the data supplied by City of Livingston operating personnel.

2.0 Contract Tasks

Task 1 - Performance Evaluation

The performance evaluation will consist of an evaluation of the performance of each wind generator as well as an evaluation of the performance of the entire wind farm. The evaluations will include an operating history of each wind generator, the total power produced by each wind generator and the entire wind farm, the average power produced per hour of operation for each generator and the entire wind farm, and the number of hours each generator was on-line.

Task 2 - Reliability Evaluation

Each wind generator's reliability will be evaluated according to the maintenance required and the down time experienced during the evaluation period.

Task 3 - Income Evaluation

The monetary income of the wind farm will be evaluated according to billing information supplied by the City of Livingston.

3.0 Performance Evaluation

3.1 Operating History

On August 2, 1982 generator No. 2 was found motoring during the daily inspection. The generator was stopped and re-started, and then performed properly. The daily performance log data indicated that this motoring incident caused no electric power loss.

On August 11, a three-month inspection of each generator was performed by the City maintenance crew assisted by Paul Laird of MultiTech. During this inspection each generator was lowered to the ground and inspected according to the Maintenance Check List contained in the Carter Wind Systems Maintenance Manuals.

This regularly scheduled maintenance inspection revealed no discrepancies in the electrical or the mechanical condition of the wind generators. As an added precaution, oil samples from each gear box were taken and sent to Carter Wind Systems for further analysis. As of this date the results of the oil analysis has not been received from Carter Wind Systems.

On August 22 generators Nos. 2 and 3 were both found motoring during the daily inspection. The generators were stopped and re-started and then operated properly. The daily performance log data indicates that no electrical power was lost due to this motoring problem.

3.2 Performance Monitoring

The attached performance chart presents the performance figures for the entire month of August.

The average wind speed for the month of August was as expected from past data and the wind generators performed very well. The electrical power output from the wind farm was as expected from previous estimates of the power available during this month.

4.0 Reliability Evaluation

Wind generator No. 2 experienced a motoring problem twice during this reporting period. Wind generator No. 3 experienced a motoring problem once during this report period. These motoring problems caused no electrical power loss due to the timely daily inspections being performed by the City maintenance personnel. None of the generators experienced down time due to any failures during this period of operation.

5.0 Income Evaluation

The total electrical power produced by the wind farm, as recorded by the kilowatt-hour meters installed at the wind generators was 11,304 kWh. The MPC main kilowatt-hour billing meter recorded 11,232 kWh. The discrepancy of 72 kWh shows an error of less that 1.0%. This small discrepancy between the City's kilowatt-hour meters and the MPC kilowatt-hour meter is within acceptable limits.

The income from the wind farm for the month of August should be approximately $598.66 for power produced at $0.0533/kWh, plus a capacity payment of $123,55 figured at $0.011/kWh. This would be a total income for August of $722.21.

Paul A. Laird

Paul A. Laird, Project Engineer

PERFORMANCE CHART

AUGUST 1982

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	2771	2883	2862	2788	11,304
Hours of Operation	315.4	348.4	351.4	399.3	399.3
Hours On-Line	738.8	739.1	739.4	739.5	739.5
Average Hourly kWhrs Output	3.8	3.9	3.9	3.8	15.3

MONTHLY PERFORMANCE MONITORING REPORT

Date: 11/3/82
Period: 9/1/82 to 9/30/82

Project Title:	Performance Monitoring of Livingston Wind Farm
Start:	12/22/81
Completion Date:	2/28/83
Contractor:	MultiTech, Inc. P.O. Box 4078 Butte, Montana 59702

1.0 Contract Objectives

The objectives of this contract are to evaluate the performance, reliability, and income of the Livingston Wind Farm based on the data supplied by City of Livingston operating personnel.

2.0 Contract Tasks

Task 1 - Performance Evaluation

The performance evaluation will consist of an analysis of the performance of each wind generator as well as an analysis of the performance of the entire wind farm. The analyses will include an operating history of each wind generator, the total power produced by each wind generator and the entire wind farm, the average power produced per hour of operation for each generator and the entire wind farm, and the number of hours each generator was on-line.

Task 2 - Reliability Evaluation

Each wind generator's reliability will be evaluated according to the maintenance required and the down time experienced during the evaluation period.

Task 3 - Income Evaluation

The monetary income produced by the wind farm will be evaluated according to billing information supplied by the City of Livingston.

3.0 Performance Evaluation

3.1 Operating History

On September 2, 1982 the guy wire cables supporting generators No. 2 and 4 were adjusted to increase their tension. These cables tend to stretch during the first year of operating time and require periodic adjustment.

The generator motoring problems that occurred several times during previous months did not appear during this monitoring period. The manufacturer of the generators is working on a fix for this motoring problem.

The average wind speed for this reporting period was 11.2 miles per hour as opposed to the historical average for September of 14.3 miles per hour. Due to this decrease in average wind speeds for the month, the electric power produced during this reporting period was lower than anticipated.

3.2 Performance Monitoring

The performance figures are presented on the attached Performance Chart for the month of September.

4.0 Reliability Evaluation

There was no down time experienced by any of the generators due to malfunctions, during this reporting period. The generators were on line virtually all of the time available during this month. Therefore, the generators were extremely reliable.

5.0 Income Evaluation

The total electrical power produced by the wind farm, as recorded by the kilowatt-hour meters installed at the wind generators was 9,836 kWh. The MPC main kilowatt-hour billing meter recorded 9,696 kWh. The discrepancy of 140 kWh shows an error of less that 1.4%. This small discrepancy between the City's kilowatt-hour meters and the MPC kilowatt-hour meter is within acceptable limits.

The income from the wind farm for the month of September should be approximately $516.80 for power produced at $0.0533/kWh, plus a capacity payment of $106.66 figured at $0.011/kWh. This would be a total income for September of $623.46.

Paul A. Laird

Paul A. Laird, Project Engineer

PERFORMANCE CHART

SEPTEMBER 1982

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	2351	2484	2560	2441	9,836
Hours of Operation	254.9	315.6	324.7	337.8	337.8
Hours On-Line	715.5	717.0	717.6	717.7	717.7
Average Hourly kWHrs Output	3.3	3.5	3.6	3.4	13.7

MONTHLY PERFORMANCE MONITORING REPORT

Date: 11/24/82
Period: 10/1/82 to 10/31/82

Project Title:	Performance Monitoring of Livingston Wind Farm
Start:	12/22/81
Completion Date:	11/30/82
Contractor:	MultiTech, Inc. P.O. Box 4078 Butte, Montana 59702

1.0 Contract Objectives

The objectives of this contract are to evaluate the performance, reliability, and income of the Livingston Wind Farm based on the data supplied by City of Livingston operating personnel.

2.0 Contract Tasks

Task 1 - Performance Evaluation

The performance evaluation will consist of an analysis of the performance of each wind generator as well as an analysis of the performance of the entire wind farm. The analyses will include an operating history of each wind generator, the total power produced by each wind generator and the entire wind farm, the average power produced per hour of operation for each generator and the entire wind farm, and the number of hours each generator was on-line.

Task 2 - Reliability Evaluation

Each wind generator's reliability will be evaluated according to the maintenance required and the down time experienced during the evaluation period.

Task 3 - Income Evaluation

The monetary income produced by the wind farm will be evaluated according to billing information supplied by the City of Livingston.

3.0 Performance Evaluation

3.1 Operating History

On October 1, 1982 generator No. 1 was lowered and inspected for a possible oil leak, however, no oil leak was found. After the inspection, during re-start procedures, generator No. 1 went into an overspeed mode several times while the operators attempted to re-start the generator. The operators then swapped the electronic control package with the package from another generator and the re-start was successful.

On October 13th, the guy cables were tightened on generator No. 1

On October 25th generator No. 1 was lowered and inspected because of a small oil spot seen on the bottom of the generator pod. No appreciable oil leak was found. However, a small spot of oil was noticed on the gear box mounting surface. Jay Carter was notified of the problem by the operators.

On October 29th generators Nos. 2 and 3 were both stopped by the out-of-balance brake. This condition was probably produced by very gusty winds, as the wind speeds on that day were high; the average wind speed was approximately 36 miles per hour.

3.2 Performance Monitoring

The performance figures are presented on the attached Performance Chart for the month of October.

4.0 Reliability Evaluation

Generator No. 1 was off-line or out-of-service for 8 hours during this month's reporting period, due to frequent inspections for oil leaks, and power line failures.

Generators Nos. 2 and 3 were off-line 4 hours each due to the operation of the out-of-balance brakes on one occasion and power line failures.

Even with the above occurrences, the total wind farm was on-line and operational 99.5 percent of the time during this reporting period, and there were no serious problems encountered. The reliability rating for this period is extremely good.

5.0 Income Evaluation

The total electrical power produced by the wind farm, as recorded by the kilowatt-hour meters installed at the wind generators was 21,809 kWh. The MPC main kilowatt-hour billing meter recorded 21,600 kWh. The discrepancy of 209 kWh shows an error of less that 0.9%. This small discrepancy between the City's kilowatt-hour meters and the MPC kilowatt-hour meter is within acceptable limits.

The income from the wind farm for the month of October should be approximately $1151.28 for power produced at $0.0533/kWh, plus a capacity payment of $237.60 figured at $0.011/kWh. This would be a total income for October of $1388.88.

Paul A. Laird

Paul A. Laird, Project Engineer

PERFORMANCE CHART

OCTOBER 1982

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	5358	5295	5506	5625	21,809
Hours of Operation	440.9	505.8	519.5	551.7	551.7
Hours On-Line	736.3	740.0	740.1	746.5	746.5
Average Hourly kWHrs Output	7.3	7.2	7.4	7.5	29.2

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APPENDIX A

SPECIFICATION FOR WIND GENERATOR

APPENDIX A -- SPECIFICATION FOR WIND GENERATORS

The following specification is in support of the City of Livingston's advertisement for wind generator bids which are to be opened June 25, 1981.

Four (4) each induction wind generators capable of generating 25 kW in a 26 mph wind at sea level. Minimum output in a 7-1/2 mph wind whereas maximum output would be 30 kW in a 30 to 40 mph wind. Generating characteristics to be 480 volt, 60 cycle, 3-phase for direct connection through owner-supplied safety interlocks to a utility line. Horizontal axis design with 50-foot galvanized pole tower and a rotor diameter of 32 feet. Blade construction of fiberglass and PVC foam. Tower guyed with four wires including turnbuckle and ground anchor assembly. Gin pole assembly for lowering the tower and one winch that is interchangeable with all four generators. All necessary support plates and assembly items to be supplied.

Controls to include as a minimum: yaw control; overload control; overspeed control; high wind protection; out-of-balance control; modular electronic; control package; and pole mounted circuit breaker. Monitoring equipment to include an instantaneous wind speed readout and an accumulating wind readout, a demand meter, and kWh output meter.

Transportation and installation of the wind generator at Livingston, Montana to be included as a separate line item in the bid. Delivery dates are to be indicated. Shop drawings; certified structural foundation drawings; electrical drawings; layout and assembly drawings; and installation, operation, and mainatenance manuals will be required from the successful bidder. An unconditional guarantee for one year after the date of installation covering materials and workmanship is required.

This specification is based on Jay Carter Enterprises Model 25 wind generator. Other equal and comparable manufacturers will be considered in this bidding process. A list of current operating installations is to be included with the bid.

APPENDIX B

LIVINGSTON WIND FARM PROJECT TASK OUTLINE

APPENDIX B -- PROJECT OUTLINE

1. BASIC DESIGN A-1
    A. Look at Current and Past Wind Data A-1
    B. List of Existing Wind Generators A-2
    C. Select Appropriate Manufacturers for Bidding A-2
    D. Establish Minimum Specifications on Wind Generators A-2
    E. Prepare Minimum Bid Package for Wind Generators A-2
    F. Develop Evaluation Criteria for Bids A-2
    G. Assist (by Telephone) in Analysis of Bids for City of Livingston Award A-3
    H. Contact MPC on the Wind Energy System Payback A-3
    I. Contact BPA on the Wind Energy System Payback A-3
    J. Contact PSC on Purchase Generation Payback A-3
    K. Analyze Payback Options of MPC, BPA, and PSC A-4
    L. Determine Utility Payback Option to be Used A-4
    M. Decision on Method of Electrical Interconnect A-4
    N. Discussion of Electrical Interconnect with MPC or BPA A-4
    O. Initiate Quarterly Report Outlining Project Status A-5
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    B. Discussion of Requirements of the Wind Generator Manufacturer A-7
    C. Obtain Survey of Old City of Livingston Airport A-7
    D. Assess Potential Locations A-7

PROJECT OUTLINE (Continued)

E. Physically Investigate the Area for Potential Problems. A-8

F. Finalize Definite Location of Wind Generators A-9

G. Establish Right-Of-Ways and Easements A-9

H. Survey Location of Generators A-9

I. Survey Right-Of-Way A-10

J. Obtain Easement of Right-Of-Way A-10

K. Draft Finalized Location on Plot Plan A-10

L. Review Plot Plant Prior to Issue. A-11

3. FINALIZE DESIGN. A-11

A. Layout Wind Machine Locations for Civil Plot Plan A-11

B. Detail Wind Machines and Accessories. A-11

C. Prepare Work Statement for Civil Engineering of Site Preparation, Roads, Fences, Gates, Foundations. A-11

D. Civil Engineer's Design A-11

E. Prepare Bid Package for Civil Construction. A-12

F. Develop Evaluation Criteria for Civil Construction Bids A-12

G. Review Civil Engineer's Design. A-12

H. Assist (by Telephone) in Analysis of Civil Bids for City of Livingston. A-13

I. Discuss Electrical Design with MPC Including Interface and Upgrade of MPC Lines. A-13

J. Prepare Work Statement for Electrical Control, Transmission Lines, Interlocks, Monitoring A-13

K. Electrical Engineer's Design. A-13

L. Prepare Bid Package for Electrical Construction A-14

PROJECT OUTLINE (Continued)

M. Develop Evaluation Criteria for Electrical Construction Bids A-14

N. Review Electrical Engineer's Design A-14

O. Assist (by Telephone) in Analysis of Electrical Bids for City of Livingston Contract Award A-14

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A. Follow Wind Generator Delivery Schedule A-15

B. Follow Construction with Site Visits During Civil and Electrical Construction Periods A-15

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E. Organize Installation, Operation, and Maintenance Information and Present it to the City of Livingston A-17

F. Outline Operations and Trouble Shooting Guide to be Included with O&M Manuals A-17

G. Provide On-Site Construction Assistance and Coordination During Installation of Wind Generators A-17

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A. Provide Adequate City of Livingston Operator Training with Jay Carter Enterprises, MPC, and MultiTech, Inc. A-18

B. Follow the Efforts of MPC, the City of Livingston, and Jay Carter Enterprises on Checkout and Debugging Procedures A-18

C. Finalize the Last Electrical Interconnections with Power Grid . A-18

D. Identify City of Livingston Responsibilities for Operation and Maintenance of the Wind Energy System A-19

E. Submit a Final Report A-19

APPENDIX C

Daily Performance and Inspection Logs

DAILY PERFORMANCE LOG

DATE: ____________

NAME OF OPERATOR: ______________________

GENERATOR NO. 1

TIME OF DAY	WIND SPEED	KILOWATT WINDOW	TOP HOUR METER

LOWER HOUR METER	WIND RUN	KILOWATT-HOUR METER

GENERATOR NO. 2

TIME OF DAY	WIND SPEED	KILOWATT WINDOW	TOP HOUR METER

LOWER HOUR METER	WIND RUN	KILOWATT-HOUR METER

GENERATOR NO. 3

TIME OF DAY	WIND SPEED	KILOWATT WINDOW	TOP HOUR METER

LOWER HOUR METER	WIND RUN	KILOWATT-HOUR METER

GENERATOR NO. 4

TIME OF DAY	WIND SPEED	KILOWATT WINDOW	TOP HOUR METER

LOWER HOUR METER	WIND RUN	KILOWATT-HOUR METER

MPC MAIN KW METER UPPER	MPC MAIN KW METER LOWER

COMMENTS - DOWN TIME - MAINTENANCE - PROBLEMS - ETC.

ATTACH EXTRA SHEET IF NEEDED

DAILY INSPECTION LOG

DATE: ____________

OPERATOR: ________________

Item	Generator			
	1	2	3	4
1. Oil Streaks				
2. Unusual Sounds				
3. Unit Operating With Wind > 10 mph				
4. Blades Downwind				
5. Vibrating Guy Wires				
6. Turnbuckels and Fasteners Secure				
7. Compare Wind Speed to Kilowatt Output				
8. Are All Generators Operating				
9. Blade Track				

Reference Jay Carter Enterprises Maintenance Manual

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ADDENDUM NO. 1

Wind Farm Electric Revenue and Expenses:
Revised Summary

Wind Farm Revenue:Sale of Electricity
Revised

Monthly Performance Reports:
November 1982

WIND FARM ELECTRIC REVENUE AND EXPENSES

Revised Summary

With receipt of November income from sales of electricity to the Montana Power Company, a revised summary of revenue and expenses can be generated, inclusive of all debits and credits from June 1981 through November 1982, as per pages 39 and 40 of the original Final Report document.

In summary, $6,494.51 has been credited to the account through November 1982, while $14,883.89 has been entered against the account, inclusive of all reimbursable expenditures through November 1982. A debit balance of $8,389.38 remains to be reimbursed the City of Livingston for expenses to-date, from future sales of electricity.

WIND FARM REVENUE : SALE OF ELECTRICITY

City Account Number 5734.31

12/22/81 - 1/7/82	$ 252.42
4/23/82 - 4/30/82	252.32
5/1/82 - 5/31/82	330.85
6/1/82 - 6/30/82	877.44
Sub-Total (FY 81-82)	$1,713.03
7/1/82 - 7/31/82	707.79
8/1/82 - 8/31/82	619.31
9/1/82 - 9/30/82	823.98
10/1/82 - 10/31/82	1,202.63
11/1/82 - 11/30/82	1,427.77
Sub-Total (To-date FY 82-83)	$4,781.48
TOTAL	$6,494.51

MONTHLY PERFORMANCE MONITORING REPORT

Date: 1/7/83
Period: 11/1/82 to 11/30/82

Project Title:	Performance Monitoring of Livingston Wind Farm
Start:	12/22/81
Completion Date:	11/30/82
Contractor:	MultiTech, Inc. P.O. Box 4078 Butte, Montana 59702

1.0 Contract Objectives

The objectives of this contract are to evaluate the performance, reliability, and income of the Livingston Wind Farm based on the data supplied by City of Livingston operating personnel.

2.0 Contract Tasks

Task 1 - Performance Evaluation

The performance evaluation will consist of an analysis of the performance of each wind generator as well as an analysis of the performance of the entire wind farm. The analyses will include an operating history of each wind generator, the total power produced by each wind generator and the entire wind farm, the average power produced per hour of operation for each generator and the entire wind farm, and the number of hours each generator was on-line.

Task 2 - Reliability Evaluation

Each wind generator's reliability will be evaluated according to the maintenance required and the down time experienced during the evaluation period.

Task 3 - Income Evaluation

The monetary income produced by the wind farm will be evaluated according to billing information supplied by the City of Livingston.

3.0 Performance Evaluation

3.1 Operating History

On November 1, 1982, the operating personnel lowered generator No. 4 and tightened the loose anemometer extension arm. The wind and tower vibration had turned the arm to a no-level position.

A small oil streak was noted from the pod drain hole on generator No. 1.

Generator No. 2 went into an overspeed and shut itself down. The operators switched electronic control packages with generator No. 4 and then both generators seemed to operate properly. Carter Wind Systems was notified of these problems.

On November 6th, generator No. 2 went into an overspeed and shut itself down. The operators removed the electronic control package to look for possible causes but found nothing suspicious. Generator No. 2 was then manually shut down and left for 12 days while operators discussed the problem with Carter Wind Systems.

On November 8th, the operators tried another electronic control package in generator No. 2. This time the spare control package did not solve the overspeed problem. This re-occurring problem does not seem to be caused by the electronic control package. Generator No. 2 was again left shut down.

On November 16th, generator No. 3 was shut down by the out-of-balance brake. The operators lowered the machine and reset the brake.

On November 17th, generator No. 3 was again shut down by the out-of-balance brake. The operators lowered the machine and reset the brake.

On November 18th, generator No. 1 was found motoring. The operators attempted to stop the machine with the hand brake. However, the hand brake was not working. When the operators lowered generator No. 1 they found that the out-of-balance brake had come on and destroyed the disc brake rotor. Generator No. 1 was then left shut down for the remainder of this reporting period, awaiting repairs by Carter Wind Systems.

On November 19th, generator Nos. 3 and 4 were stopped by the out-of-balance brake. Both machines were lowered and inspected for possible problems, however, no problems were found. Both generators were raised and restarted without any problems.

Generator No. 2 was also inspected for possible causes of the overspeed problem. The operators found a cracked wire end terminal where the signal wire attaches to the slip rings. The terminal was replaced and the generator was restarted. Generator No. 2 then operated properly.

On November 21st, generator No. 2 was found motoring. The operators shut down the generator and restarted it, and then the generator operated properly.

On November 23rd, generator No. 2 went into an overspeed and shut itself down. The operators found a broken wire in the electronic control package. After replacing the broken wire, the generator was restarted and is running normally.

3.2 Performance Monitoring

The performance of the wind farm during the November reporting period was severely hampered by re-occurring electronic control problems. The performance figures show that the down time experienced was 20% of the possible operating time. The performance figures are presented on the attached Performance Chart for the month of November.

4.0 Reliability Evaluation

Generator No. 1 was off-line or out-of-service for 12 days during this month's reporting period due to the brake disc failure.

Generator No. 2 was off-line for 12 days during this month due to re-occurring electronic control problems.

Generator No. 3 was off-line for 1 day due to an out-of-balance caused by gusty winds.

The entire wind farm was on-line and operating properly approximately 80% of the available time in this reporting period. The reliability rating for the month of November is therefore lower than the rating of 97% for previous months.

5.0 Income Evaluation

The total electrical power produced by the wind farm, as recorded by the kilowatt-hour meters installed at the wind generators was 21,228 kWh. The MPC mail kilowatt-hour billing meter recorded 20,736 kWh. The discrepancy of 492 kWh shows an error of 2.3%. This discrepancy between the City's kilowatt-hour meters and the MPC kilowatt-hour meter is just barely within the acceptable limits.

The income from the wind farm for the month of November should be approximately $1105.23 for power produced at $0.0533/kWh, plus a capacity payment of $228.10 figured at $0.011/kWh. This would be a total income for November of $1333.33

Paul A. Laird

Paul A. Laird, Project Engineer

PERFORMANCE CHART

NOVEMBER 1982

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	3568	4063	6559	7038	21,228
Hours of Operation	263.8	314.5	495.9	527.5	527.5
Hours On-Line	427.9	418.3	697.1	718.0	718.0
Average Hourly kWHrs Output	8.3	9.7	9.4	9.8	29.6

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PERFORMANCE CHART

DECEMBER 1982

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	303	2557	3068	4498	10,426
Hours of Operation	19.5	181.9	213.2	291.1	291.1
Hours On-Line	21.2	254.0	288.0	448.7	448.7
Average Hourly KwHrs Output	14.3	10.0	10.7	10.0	23.2

PERFORMANCE CHART

JANUARY 1983

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	7080	3939	4549	1727	17,295
Hours of Operation	482.8	217.1	352.6	214.1	482.8
Hours On-Line	671.8	336.2	639.6	199.2	671.8
Average Hourly KwHrs Output	10.5	11.7	7.1	8.7	25.7

PERFORMANCE CHART

FEBRUARY 1983

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	6931	5505	4049	7043	23,528
Hours of Operation	502.1	454.8	329.3	508.5	508.5
Hours On-Line	626.4	594.4	546.8	599.9	626.4
Average Hourly KwHrs Output	11.0	9.3	7.4	11.7	37.6

PERFORMANCE CHART

MARCH 1983

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	5456	5950	5570	5658	22,634
Hours of Operation	483	280.6	499.6	488.9	499.6
Hours On-Line	719.8	719.7	719.9	720.1	720.1
Average Hourly KwHrs Output	7.6	8.3	7.7	7.9	31.4

PERFORMANCE CHART

APRIL 1983

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Wind Farm Total
KwHrs Output	3865	2629	3002	2988	12,484
Hours of Operation	300.9	293.9	311.6	305.9	311.6
Hrs. On-Line	521.9	363.2	502.0	502.1	521.9
Averge Hourly KwHrs. Output	7.4	7.2	6.0	5.6	23.9

PERFORMANCE CHART

May 1983

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Generator No. 5	Wind Farm Total
KwHrs Output	2955	2748	3103	3126	2426	14,358
Hours of Operation	413.3	417.7	440.1	429.7	584.1	584.1
Hours On-Line	716.9	718.1	718.1	717.8	716.9	718.1
Average Hourly KwHrs Output	4.1	3.8	4.3	4.4	3.4	20.0

PERFORMANCE CHART

JUNE 1983

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Generator No. 5	Wind Farm Total
KwHrs Output	2990	2753	3124	927	2218	12012
Hours of Operation	438.1	456.7	470.2	130.7	400.5	470.2
Hours On-Line	814.6	814.8	814.8	289.4	806.6	814.8
Average Hourly KwHrs Output	3.7	3.4	3.8	3.2	2.7	14.7

PERFORMANCE CHART

JULY 1983

	Generator No. 1	Generator No. 2	Generator No. 3	Generator No. 4	Generator No. 5	Wind Farm Total
KwHrs Output	3088	1360	3148	1738	2779	12,113
Hours of Operation	347.9	146.3	366.0	173.2	351.7	366.0
Hours On-Line	633.1	220.6	632.8	289.0	533.4	633.1
Average Hourly KwHrs Output	4.9	6.2	5.0	6.0	5.2	19.1

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